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Butt Weld Pipe

Mechanical Engineering

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BUTT WELD PIPE

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

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OF Mechanical Engineer

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BUTT WELD PIPE

The use of iron and steel pipes and tubes for conveying and delivering fluids and gases is of comparatively recent origin, though culverts of brick and cement are mentioned in very ancient history.

However lead pipes were used by the Romans and Pliny (23 A.D.-79 A.D.) states that "in order to raise water up to an eminence leaden pipes must be employed."

In the year 1812,Henry Osborn of Birmingham, England, obtained letters patent for "machinery for welding and making barrels of firearms and other cylindrical articles."

The machinery consisted of a tilt hammer with swages which brought the heated edges of the skelp together and welded them.

In 1824, James Russell of Wednesbury filed a specification, No.4892, setting forth "an improvement in the manufacture of tubes for gas and other purposes." The tilt hammer was used for welding, as shown in Fig.1, but the weld was formed either with or without a mandrel, the edges being butted against each other and not overlapped as in the gun barrel welding.

The tube was finished between rolls in conjunction with a mandrel, as shown in figures 2 and 3. This is the first mention of the discovery that a sound weld could be made by pressing or forcing the abutting edges of the tube-skelp against each other.

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In the following year, 1825, Cornelius Whitehouse of Wednesbury, invented the process of butt-welding wrought iron tubes, which has been the basis of the processes used to the present time.

In view of the historical significance of this invention or process, the inventor's description, together with his drawings, are here given.

"I prepare a piece of flat iron, commonly called plough-plate iron, of a suitable substance and width, according to the intended calibre of the tube. This piece of flat iron is prepared for welding by being bent up on the sides, or, as it is commonly termed, turned over, the edges meeting, or nearly so, and the piece assuming the form of a long cylindrical tube. This tube is then put into a hollow fire, heated by a blast, and when the iron is upon the point of fusion it is to be drawn out of the furnace by means of a chain attached to a draw bench, and passed through a pair of dies of the size required, by which means the edges of the iron will become welded together. The apparatus which I employ for this purpose is shown at fig.4, which is a side view of the furnace A, and of the draw bench B, with its spur wheel C, which may be put in operation by a hand winch, or by attaching its axle to the moving part of a steam engine. D is a screw press, in which the dies are placed for swaging and uniting the edges of the iron tube E as it passes through. A front view of this screw press is shown at fig.5, and one of the dies removed from the press is shown at fig.6. The iron tube E, having been heated to the point of fusion in the furnace A, is drawn out by the chain of the draw bench, and the screw of the

press D being turned so as to bring the dies to their proper point of bearing, the two edges of the iron become pressed together, and a perfect welding of the tube is effected. The screw clamp or other fastening F, by which the end of the tube is held and attached to the chain, is now opened, and the tube removed. The reverse side of the tube is then grasped by it, and that part which has not been welded is introduced into the furnace, and after being heated is drawn through the dies and welded in the manner above described. The process of welding these tubes may be performed without the screw press and dies above described. A pair of pinchers, as shown at fig. 7, may be employed instead, having a hole for the tube to pass through similar to the dies. One arm and chap of these pinchers is shown in section at the lower part of fig.7, for the purpose of exhibiting the conical figure of the hole which the tube E is to pass through as it is drawn out of the furnace by the chain of the draw bench. A workman brings the pinchers against the standard at a steadying place, and as the tube passes through the hole of the pinchers the welding of the edges of the iron is effected.

I have thus described the modes which I have employed and found fully to answer the purpose in welding tubes of iron, but I do not confine myself to the employment of this precise construction of apparatus, as several variations may be made without deviating from the principles of my invention, which is to heat the previously proposed tubes of iron to a welding heat - that is, nearly to the point of fusion -and then, after withdrawing them from the fire, to pass them between dies, or through holes, by which the edges of the heated iron may be pressed

together and the joint firmly welded. The advantages of this tube compared with those made in the ordinary way are these: The iron is considerably improved by the operation of the hollow fire, the heat being generally diffused. The length of the pieces of tube thus made is likewise a great advantage, as by these means they may be made from 2 ft. to 8 ft. long in one piece, whereas by the old modes the lengths of tubes cannot exceed 4 ft. without considerable difficulty, and, consequently, an increased expense. These tubes are likewise capable of resisting greater pressure from the uniformity of the heat throughout at which they have been welded; and, lastly, both their internal and external surfaces are rendered smooth, and greatly resembling drawn lead pipes."

This patent was assigned by Whitehouse to James Russell and held by him until its expiration, on February 26th, 1845.

In the United States the first furnace for the manufacture of butt-weld tubes was built between 1830 and 1834, by the firm of Morris, Tasker and Morris, in the cellar of the shop at Third and Walnut Streets, Philadelphia, the welder being William Griffiths, who had followed that trade in England.

In 1836, this same firm erected a mill and machine shop on the block of ground now bounded by Fourth, Fifth, Morris and Tasker Streets. This was known as the Pascal Iron Works.

In 1849, a building was erected, having space for nine welding furnaces, together with the necessary machinery.

On July 1,1847, James J.Walworth of the firm of Walworth and Nason of Malden,Mass., sailed for England to inves-

tigate the tube making industry in that country.

From July 17 to July 22,1847, he visited the Russells at Wednesbury, Staffordshire, and at Handworth; he inspected the Works and sailed for home Sept.4, bringing with him plans for the erection of a tube mill.

The following year the Wanalancet Tube Company was formed, and on September 18,1848, James Ridley and Mr.Fellows, from Jas. Russell and Sons, England, came to assist in the erection of the mill.

The officers and directors of the Wanalancet Tube Company were as follows:--

James J.Walworth---------President and Treasurer
J.Nason------------------Consulting Engineer
James L.Walworth)
L.Nason---------)--------Directors
J.Nason---------)

On November 3, 1849, the first tubes and pipe, (one inch pipe, three fourth inch pipe, and three inch flues) were made.

This Works continued in operation until 1853.

In 1848 and 1849, Walworth and Nason bought wrought iron pipe from Morris, Tasker and Morris and a comparison of the prices per foot prevailing at that time with the present prices is given below:--

SIZE INCHES	PRICE 1849	PRICE 1907
2,1/2"	.601	.114
2"	.293	.071
1,1/2"	.166	.054
1,1/4"	.148	.045
1"	.104	.033
3/4"	.074	.023
1/2"	.065	.020
3/8"	.056	.014
1/4"	.046	.015

Among the other early pipe mills established in addition to the two named above were,--

Griffith Bros., Philadelphia.
Seyfert,McManus & Co., Reading,Pa.
Allison and Co., Philadelphia.
Girard Tube Co., Philadelphia

There were also small mills at Exeter,N.H.,Taunton, Brooklyn, Jersey City, Conshocken and two near Boston.

All of these have gone out of business except that of Seyfert, McManus & Co., which was later succeeded by The Reading Iron Company, which company to-day is the largest manufacturer of strictly puddled wrought iron pipe.

West of the Alleghenies,the first mill to make pipe was that of Spang-Chalfant Co., at Pittsburgh, who started a mill about 1860. This firm is still making pipe and tubes.

In 1863 or 1864, A.M.Byers, who had been a partner in the above firm, withdrew and started a pipe mill, the firm name being A.M.Byers and Co., as it is to-day.

In 1865, Crane Company of Chicago, built a butt weld pipe mill in Chicago and have been manufacturers of butt weld pipe during most of the years since that time.

The following account of the evolution of the National Tube Company, printed in "The Valve World" of March,1906, published by Crane Co., Chicago, Ill., is so complete that it is reprinted in its entirety.

"About 1865 the Flagler brothers, John H. and Harvey K., trading under the name of Flagler & Company, had their headquarters in Boston and handled various lines of iron merchandise. They were the representatives of Morris,Tasker & Co. in the New England market for the sale of boiler tubes, etc,

although they handled Scotch tubes largely when the market conditions warranted. Owing to some disagreement between John H. Flagler and the managing director of this firm, the agency was withdrawn and Flagler & Company found themselves unable to make satisfactory arrangements for a supply of American tubes. Being energetic and knowing the mercantile part of the business thoroughly, they determined to enter the manufacturing field themselves. They bought some tube machinery which had been erected in New Jersey by the Bergen Tube Works, and which had been dismantled owing to that concern's lack of success. The Flaglers secured the services of George Matheson, a leading practical engineer, who was superintendent of the East River Iron Works, to superintend the erection of their plant, which they located at East Boston. When the mill was nearing completion, the Flaglers persuaded Mr.Matheson to remain and superintend the operation of the plant. The plant was put in operation late in 1869 with one anthracite coal furnace. Later a second and a third furnace were added.

The Flaglers were joined in the enterprise by the late J.C.Converse, a well-known merchant of Boston, who took the presidency of the newly formed company, which was known as the National Tube Works Co., the capital being $300,000. Mr.Converse retained the presidency until 1891, a term of over twenty years.

Instead of hammering this new concern, and endeavoring to drive it out of business, as had been the usual policy of Morris,Tasker & Co., they sneered at the Flagler brothers and predicted their failure. The business,however, was successful from the start. John H.Flagler, the senior member of the former

partnership, proved his energy in the sale of their new goods and Mr.Matheson, with his great mechanical ability, soon put the company far in advance of their competitors in the art of manufacturing tubular goods.

Finding that the demand for boiler tubes was not sufficient to keep the plant running full capacity, John H.Flagler visited the oil country and made a study of the needs of the oil business, and, as a result, the National Tube Works Co. put on the market a line of goods to meet the demands of that class of trade.

Before long, the management saw that they were too far away from their base of supplies and that New England, as an iron district, was on the wane. As they had been buying iron strips from Pittsburg manufacturers, J.E.Converse and John H.Flagler visited Pittsburg for the purpose of finding a suitable site for a branch mill, and just missed locating on the present Carnegie site, which, at least so they thought at the time, was a little too important for their works. McKeesport was finally selected as being a satisfactory location. A defunct rope-walk property was purchased, and on this site was erected a structure in which they proceeded to install four furnaces. The first piece of two inch tube was pushed through the rolls in August, 1872. The furnaces installed were the first gas furnaces for such use erected in this country under the Siemens patent, for which the National Tube Works Co. held the exclusive right for pipe manufacture. In the spring of the following year the whole structure was burned. As soon as possible, reconstruction was commenced and before very long the new fire-proof mill was running. The East Boston mill was abandoned in 1874.

The capital stock about this time was increased from one million to $2,500,000. About the same time, which was long before the day of trusts and combinations, the manufacturers had various associations for the enactment of rules and laws to govern their business. One of their organizations was the "Big Six" and consisted of the National Tube Works Co., Allison Mfg.Co., Seifert, McManus & Co., (now Reading Iron Works) Evans, Dalzell & Co., Spang, Chalfant & Co., and Morris, Tasker & Co. These manufacturers were all lap-welders, as they were then called. Byers & Co. at that time were only making butt-weld goods. All of the "Big Six" manufactured boiler tubes and oil country goods, and their chief object in organizing was to fix prices and regulate the distribution of these articles.

About 1880, the National Tube Works Co.'s management decided to roll their own iron and built the National Rolling Mills. They were the first to put in a mill for such purpose. Being before the age of steel, various puddle mills formed a part of this rolling mill.

In 1890, the Monongahela Furnace Co., which was controlled, as far as its output was concerned, by the National Tube Works Co., was started. Prior to that time, the National Tube Works Co. had built a forge for the manufacture of their own charcoal blooms, and a little later the Boston Iron & Steel Co. was started for the manufacture of small strips.

The capital of the National Tube Works Co., which had been $2,500,000. was increased by $500,000 additional stock, which was issued for cash, the company requiring more money, notwithstanding their large earnings. The stock of the Monongahela Furnace

Co. was one million. The stock of the Wharton Works (known as the Republic), another subsidiary company, was $250,000. In 1891, amalgamation was made of these raw material concerns with the company proper. The Massachusetts charter was surrendered and a new charter taken out in the same name, under the laws of New Jersey, with a capital stock of $11,250,000, one-half preferred and one-half common stock. Shortly after, the National Tube Works Co. erected a steel plant and the company found themselves manufacturing everything pertaining to their business. They did not,however, own ore mines.

About 1885, the Riverside Iron Works,(of Wheeling,West Va., whose superintendent, Mr.Peter Boyd, is now General Superintendent of The National Tube Company,) with their aggressive, up-to-date management, determined to utilize some of their Bessemer steel for the manufacture of pipe. Bessemer steel was not made in those days so uniform or low in carbon as is done to-day. The National people watched the operation of the Riverside people with great interest. In 1892, the National Tube Works Co. sent E.C.Converse, who, in 1887, had succeeded Mr.Flagler as general manager, and their general superintendent, Peter Patterson, abroad with instructions to make a thorough examination of the use of steel by foreign tube manufacturers. As a result of the report of this committee, the company very soon commenced the manufacture of steel tubing.

The great strides made by the National Tube Works Co. in the development of improved and economical methods of manufacturing pipe were primarily due to the mechanical ability of George Matheson and Peter Patterson, who had been a journeyman

mechanic under Mr.Matheson at East River Iron Works, New York, and subsequently chief mechanical engineer for Mr.Matheson at the National Tube Works Co., and who succeeded Mr.Matheson as superintendent of the company's tube and pipe mills upon the retirement of the latter in 1880, when he organized the American Tube & Iron Co. Mr.Patterson held the position of superintendent until 1897, in which year he took charge of the new seamless tube department which had been built in that year under his directions. In 1903 he became consulting engineer for the National Tube Co., which position he still holds.

It is interesting to note that George Matheson and Peter Patterson were both natives of the same Scotch town, Jedburgh. Mr.Matheson served a rigid apprenticeship in the famous George Stephenson works at Newcastle-on-Tyne. His indenture bears the signature of Robert, son of George Stephenson. Mr.Matheson came to America about 1850, when he was about twenty-two years old, and soon gained a reputation as a high-class mechanic and a hard, daring, and original worker .

The American Tube & Iron Co. was the outgrowth of a plant in Middletown, Pa., known as the Middletown Tube Co., incorporated in 1873 with a capital stock of $100,000. While there was some local capital invested in the Middletown Tube Co., it was controlled by a Philadelphia company known as the Philadelphia Gas Trust. In March, 1880, George Matheson and his sons purchased the Middletown Tube Co. and completely reconstructed it. The new company was very successful, largely due to the efficiency of its manufacturing departments. In November, 1888, in order to increase the capacity of both the Middletown plant

and the Youngstown, O., plant - which had been built subsequently - the capital was increased to one million dollars. In 1899, the company was turned into the consolidation known as the National Tube Co. At this time, the producing capacity at Middletown was about 350 tons per day and at Youngstown about 150 tons per day.

From the time the American Tube & Iron Co. was originally organized, until it was turned into the National Tube Co. consolidation, the capital stock of the American Tube & Iron Co. was very largely owned and controlled by George Matheson and his family, the outside interest being comparatively small.

In 1893 an attempt was made by Messrs. Converse and Cromwell to merge all the important pipe concerns into a giant corporation, but they were not successful. Efforts were again made in 1898, resulting in the formation of the present National Tube Co. On the 1st day of July, 1899, there was taken over by purchase the following plants:

National Tube Works Co. (which company was in turn a consolidation of: National Pipe Dept., Boston Iron & Steel Works, National Rolling Mills, Monongahela Furnaces, Monongahela Steel Works, Republic Iron Works, U.S. Seamless Tube Works, and McKeesport Connecting R.R.); Cohoes Tube Works; National Galvanizing Works; Syracuse Tube Works; Pennsylvania Tube Works; Ohio Tube Co.; Allison Mfg.Co.; Morris, Tasker & Co.; Delaware Iron Works; Chester Pipe & Tube Co.; American Tube & Iron Co.; Oil Well Supply Co.'s Elba Iron Works and Continental Tube Works; Riverside Iron Works and Pittsburg Tube Works.

The purchase of these plants placed in the hands of the

company about seventy per cent of the producing capacity of the United States, and thoroughly equipped them for the manufacture of all classes of tubular goods from $\frac{1}{8}$ inch to 30 inches diameter. Some of the plants, however, were far from modern and many of them required the purchase of raw material in the open market for their operation, as they were neither fitted with blast furnaces nor steel plants.

From time to time, certain of these plants were abandoned because of the high cost of production at their several locations, so that of the plants included in the original purchase, the following are the only ones now in operation:

National Tube Works Co., McKeesport, Pa.; National Galvanizing Works, Versailles, Pa.; Syracuse Tube Works, Syracuse, N.Y.; Pennsylvania Tube Works, Pittsburg, Pa.; Allison Mfg. Co., Philadelphia, Pa., American Tube & Iron Co., Youngstown, O., and Middletown, Pa.; Elba Iron Works and Continental Iron Works, Pittsburg, Pa.; Riverside Iron Works, Wheeling, W.Va.

To this capacity, however, has recently been added an entirely new tube works, located at Lorain, O., with a capacity of approximately 1,500 tons per day. McKeesport works are also under course of reconstruction, which will be completed within a short time, making that also a strictly modern mill. From time to time, blast furnaces and steel plants have been added so that now, with a total capacity of approximately 1,000,000 tons of tubular goods per annum, the National Tube Co. are practically self-contained from the ore through.

Possibly the best idea of the growth of the National

Tube Co. can be given by a statement of orders received for the first year of operation and for the last year:

Orders received for year 1900 amounted to 423,000 tons;
" " " " 1905 " " " 767,000 "

Possibly a more definite idea can be given of the production if it is stated that the company's annual production in feet of tubular goods of the various sizes closely approximates 450,000,000 feet.

Edmund C.Converse was the first president of the company, and was succeeded (when in 1902 the company became a subsidiary corporation to the United States Steel Corporation) by Frank J. Hearne, formerly general manager of the Riverside Iron Works. He, in turn, was succeeded by the present president, Wm.B.Schiller, who had previously been first vice-president of the company."

In 1883 a pipe mill was built in Kewanee, Ill., by the Haxtun Steam Heater Co., now the Western Tube Company, which is controlled by the National Tube Co. This mill has been in continuous operation since that date, and a considerable portion of its success in so isolated a location has been due to the mechanical ability of Mr.A.M.Hewlett, now President of the Western Tube Co., and of Mr.W.B.Sandford, who for twenty-two years was Superintendent of the pipe mill.

We will next take up a number of the patents which mark changes in the process of making butt-weld pipe from the time of Cornelius Whitehouse until the present day.

The earliest patent issued in the United States relating to the manufacture of butt-weld pipe was No.6017,dated Jan.9,1849, and issued to J.McCulley for a pair of die tongs

through which the flat strip was drawn; and by the use of several of these tongs with various shaped jaws, the flat strip was finally shaped into a circle with the edge butted and ready for welding.

This arrangement was superseded by the Blakey Skelping Die, Patent No.70397, dated November 5,1867, which consisted of a fixed funnel-shaped die, slotted along the top. Through this slot was introduced a pair of toothed jaw tongs which grasped the heated strip; by means of a draw bench chain the tongs and strip were drawn through the die and the flat strip shaped into a circle with the edges butted against each other.

This idea, with modifications, is still used in forming the skelp for lap weld pipe.

On March 25, 1875, a patent was granted to George Matheson of McKeesport,Pa., for a device consisting of a fixed bell-holder, slotted at the top, and a funnel-shaped bell.

Prior to this time all pipe was made from a strip of iron which was heated once, drawn through a die, similar to the Blakey die, as mentioned before, and then reheated to a welding heat; being then drawn through a pair of funnel-jawed welding tongs.

Welded to the strip of skelp at one end was a piece of round iron, the tag, with a knob on the end which was grasped by the buggy which engaged with the draw bench chain.

By the use of the funnel-shaped bell, mentioned in above patent, the two operations of skelping and welding were combined, materially decreasing the cost and increasing the rate of production. See Figure 8.

The furnaces at this time were only long enough to weld one half of a pipe at one heating, so that a large number were welded throughout one half of their length, and then later were turned around and welded the remainder of the length.

After welding, the common method of bringing to size and straightening was the table. This apparatus consisted of a stationary iron table, above which a large heavy iron plate was suspended from its corners. This was moved by an eccentric and caused the pipes to roll about as the swinging plate pressed upon them.

On July 8, 1875, a patent was granted Mildred Blakey of Etna, Pa., for a set of cross rolls for welding and finishing pipe.

This consists of two rolls held in a housing; each roll is somewhat concave in the direction of its length, and is set not parallel with the line of feed, but angularly thereto, and crosswise thereof, so that a plane passing lengthwise through the axis of each roll and cutting the line of feed, will make an angle therewith.

The degree of curvature may be varied according to the size of the pipe, so that the rolls have a long bite on the pipe, and as the rolls revolve, the pipe is revolved between them and is fed longitudinally by them.

A set of rolls embodying this principle is even now used in a great many mills for rounding and straightening the pipe after it has passed through the bell and one set of sizing rolls.

In the construction of agricultural machinery there arose a demand for butt-weld pipe of a hollow square or rectangu-

lar cross section, thus giving a light, rigid section with flat surfaces to which could be bolted castings.

On August 23, 1887, William B.Sandford of Kewanee, Ill., was granted a patent on the manufacture of square metal pipe, the method of which consisted of welding the pipe by drawing a strip of flat skelp through a round funnel-shaped bell, as in the manufacture of round pipe; then changing the round section to a square section by drawing the pipe through four or six dies which gradually changed the round outline to a square outline.

The pipe was finally passed through one set of rolls and a long straight die to perfectly flatten the sides and take out any twist.

After each draw the pipe was shoved back into the furnace and reheated before passing through another die.

On May 8,1888, Thomas J.Bray of Wheeling, W.Va., was granted a patent on the method of manufacture of angular tubes, which differed from Mr.Sandford's patent in that the pipe was lap welded in rolls having gothic-shaped grooves, and then passed through several passes of rolls having the outlines gradually changing from the gothic shape to a square, each time the pipe being supported internally by a mandrel. This saved reheating the pipe between draws.

On September 3,1889, another patent was granted to William B.Sandford of Kewanee, Ill., on "Method of Making Square Metal Pipe".

The method consisted in reducing a round pipe to a square pipe by passing it, unsupported internally, through three sets of rolls, the grooves of which in the first two sets, were

made concave instead of straight, thus preventing collapse of the pipe. This method is still in use, with the exception that only two passes, instead of three, are now used.

For many years the plant at Kewanee, Ill., was the only one making square and rectangular pipe, as no method was devised which was as rapid or cheap as that covered by Mr.Sandford's second patent.

Figure 9 shows a view of the passes used in changing the round pipe to a square pipe.

Until 1889 the draw bench was mounted stationary in front of the furnace, there being only three or four blanks in the furnace at one time, and these were moved over in line with the bench before being drawn.

On December 3,1889, Peter Patterson of McKeesport,Pa., was granted a patent on "Apparatus for Welding Tubing", which consisted of a draw bench pivoted at the end farthest from the furnace, the end at the furnace swinging in an arc across the opening.

Attached to a crosshead on the swinging end was a piston rod leading to a cylinder, and by means of steam or hydraulic power,the end of the bench was quickly and easily swung across the mouth of the furnace and its position held under positive control.

This marked another distinct advance in the art, as by the use of this apparatus, many more sheets could be charged in the furnace at one time, the labor of moving the heated blanks into position in front of the bench was done away with,and the blanks received a more uniform heat.

This type of bench, with few changes, is still in use in nearly all butt-weld mills.

Figure 10 shows a plan and elevation of the draw bench, furnace and driving cylinder.

Until 1890, the flat strip, after being rolled and sheared into lengths in the rolling mill, was then heated at one end and the end folded over and welded around one end of a round bar, about five feet long, on the opposite end of which was a knob or button. This was called the tang, or more generally, the tag. This was to insure a certain means of pulling the strip of skelp through the welding bell.

The expense of tagging each piece was of course considerable, and inventive minds naturally began to seek for a practical method of doing away with the tag.

The first patent issued for a detachable tag was issued on March 11,1890, to J.F.Ordner, of McKeesport, Pa.

This tag consisted of a round bar of iron, split longitudinally horizontally, the inside of the lower half having a lug which, when the two hal ves were forced together, by a ring, projected upwards through a hole which had been punched in the strip of skelp and into the top half of the tag. The two halves were closed by means of a ring slipped up onto a tapered portion of the tag. After welding, the ring was slipped backward and the tag detached from the pipe. The welded tag formerly was cut off by a shear, near the end of the draw bench, before the pipe was finished in the rolls.

Ordner's tag was not practical and did not come into general use.

Until this time the button, or knob, on the end of the tag, had been engaged by a fork on a little four wheeled buggy or truck, on the opposite end of which was a hook which was dropped into the draw chain when the strip was to be pulled through the bell. This buggy was followed along the bench by the "buggy runner", a boy, who, when the strip had been drawn through the bell, withdrew the hook from the chain, released the knob of the tag from the buggy, and then rolled the buggy back along the bench to the furnace. See Figure 11.

This work was laborious, especially after a larger number of sheets were heated in the furnace at the same time. To reduce this labor, Mr.Peter Patterson invented a hook, as shown in Figure No.12, which slipped over the tag end, engaged the knob on the tag, and then was pressed downward to engage with the draw chain. A modification of this hook is used to-day to engage with the knob on the end of the drawing tongs and then with the draw chain. One form in use is shown by Figure No.13.

During quite a period of time, Mr.A.M.Hewlett and Mr. W.B.Sandford of Kewanee, Ill., had been experimenting with various forms of pipe drawing tools and pipe drawing tongs, and finally success crowned their efforts.

On April 16,1895, there were issued to Mr.A.M.Hewlett six patents, and to Mr.W.B.Sandford three patents, covering a variety of styles of pipe drawing tools and tongs. The use of these tongs greatly increased the speed of welding pipe and materially decreased the cost, as it did away entirely with the tagging furnace , consumption of tagging iron, tagging fuel,etc.

These tongs were adopted by the National Tube Works Co.

and it was stated that during the first year alone their use saved that company one hundred thousand dollars.

Two styles of tongs were adopted, one of which, figure No.14, being for 3/4" and smaller, and the other, figure No.15, for 1" to 3".

The use of practical pipe drawing tongs paved the way for the next radical departure in the art.

Heretofore, the plates with the tags attached, had been charged from the same end of the furnace from which they were drawn when heated, the welder and the men charging the cold strips working in the same space, which hampered all of them. But this method became obsolete soon after the advent of tongs.

On April 20, 1897, a patent was granted to Mr. Peter Patterson of McKeesport, Pa., on "Manufacture of Tubing", which covered the idea of introducing the cold sheets through an opening in the rear or back end of the furnace. By this means, a cold plate was charged immediately, so that the heated plate was hardly through the bell before the cold plate was entirely in the furnace. This method also made the first end of the plate remain in the furnace the same length of time as the back end, whereas formerly the first end charged was the last end drawn through the bell, which rendered liable the burning of the back end of the pipe. See Figure 16. This step also made possible the mechanical charging of the plates. Formerly they were all shoved into the furnace by two men, the work on the heavier sizes being very arduous. Since then, mechanical chargers have been put into operation, the common type being a structural frame work on which the load of skelp rests, this frame work moving back and forth

upon rails behind the furnace, and one sheet at a time is laid in position and shoved into the furnace by a finger on a chain or cable. The lateral motion of the charger and the forward motion of the finger are accomplished by electric motors, controlled by an operator who rides with the mmachine.

As by this time the method of handling had become very simple, and the production of pipe greatly increased,and the cost reduced, it seemed as if no new radical departure from the established method was to be expected.

However, Mr.Peter Patterson, in a letter dated June 16, 1897, to Mr.W.B.Sandford, says,--

"I don't see how we can improve very much on our present system of making butt pipe. If another step forward is made I think it will have to be making two lengths at one time, but who will have the nerve to build a furnace long enough to do this is the question; suppose you try it first."

The first furnace forty feet long was built at the McKeesport plant of the National Tube Co., under the direction of Mr.Peter Patterson, and as he had foretold, was successful. A patent was issued to him in December,1902, for apparatus for the manufacture of double-length tubing. At the new plant at Lorain, Ohio, started in 1906, three such furnaces are in successful operation.

The operation is similar to that of a single length furnace,except that a strip about thirty eight feet long is welded at one draw,and then is cut into two pieces,which are of merchant length.

With the use of pipe as a method of conveying fluids and gases, came the necessity of connecting pieces of pipe together, also the connection with valves, fittings of all kinds, etc.

The method most commonly in use is the socket or coupling, which is a cylindrical ring, threaded on the interior. Into this ring are screwed the pieces of pipe, which bear an external thread.

In the United States, (as is still the condition in England) until 1885, a rather chaotic condition existed as to the standard sizes of pipe and the formation of thread.

About 1840, the tapered thread for making tight connections was first put into use by Walworth and Nason of Boston.

Mr.Robert Briggs, an eminent heating engineer, associated with this firm, adopted and published a table of sizes, thicknesses and threads for each size of pipe in general use. This was adopted by many manufacturers, but no concerted action was taken until 1885.

At the sixth annual meeting of the American Society of Mechanical Engineers, held at Boston in November, 1885, a committee was appointed by the president of the society to confer with manufacturers of pipe, pipe dies, and pipe fittings, for the purpose of establishing a series of standard gauges for pipes and pipe threads, so that a uniform system might prevail throughout the country.

The committee met in Hartford in February, 1886, and its first report was presented at the seventh annual meeting of the society, which was held at New York in November, 1886.

The opinion of the committee was in favor of the Briggs standard, and they urged co-operation on the part of the manufacturers to maintain that standard. Such co-operation was readily given by the Manufacturers of Wrought Iron Pipe and Boiler Tubes, the Cast Iron Fittings'Association, the Manufacturers of Brass and Iron, Steam, Gas, and Water Work, and others.

A joint conference was held in June,1886, with a committee of pipe manufacturers and it was decided to ask each manufacturer to send to the Pratt & Whitney Co., of Hartford, sample pieces of all sizes of pipe from six inches down, threaded on one end, to be tested by the Pratt & Whitney Company and compared with the Briggs standard gauges. Thirteen manufacturers complied with the request and furnished the desired samples, which were then carefully tested; the results of the tests were tabulated and submitted to the Pipe Manufacturers' Association, at its regular convention, held at Philadelphia in August,1886. The variations from the Briggs standard, as shown by the tests, were small except in the cases of the three-fourths and one inch sizes. Another conference of committees was then held, and finally, in October, 1886, the Briggs standard was definitely adopted by the Manufacturers of Wrought Iron Pipe and Boiler Tubes,and in December of the same year, it was also adopted by the Manufacturers' Association of Brass and Iron, Steam, Gas,and Water Work; so that now it may be regarded as a national standard.

The following description of the Briggs standard is taken from the paper of Robert Briggs, C.E., in the Excerpt Minutes of Proceedings of the Institution of Civil Engineers of Great Britain, Vol.lxxi., Session 1882-83, Part 1.

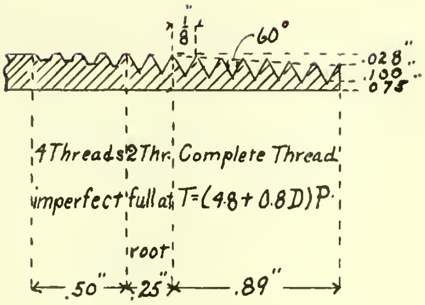
"The taper employed for the conical tube-ends is uniform with all makers of tubes or fittings, namely an inclination of 1 in 32 to the axis. Custom has established also a particular length of screwed end for each different diameter of tube. Tubes of the several diameters are kept in stock by manufacturers and merchants, and form the basis of a regular trade in the apparatus for warming by steam. A knowledge of all these particulars is therefore essential for designing apparatus for the purpose. The ruling dimension in wrought-iron tube work is the external diameter of certain nominal sizes, which are designated roughly according to their internal diameter. These nominal sizes were mainly established in the English tube trade between 1820 and 1840, and certain pitches of screw-thread were then adopted for them, the coarseness of the pitch varying roughly with the diameter, but in an arbitrary way utterly devoid of regularity. The length of the screwed portion on the tube end varies with the external diameter of the tube according to an arbitrary rule-of-thumb; whence results, for each size of tube, a certain minimum thickness of metal at the outer extremity of the tapering screwed tube-end. It is the determination of this minimum thickness of metal, for the tapering screwed end of a wrought-iron tube, which constitutes the question of mechanical interest.

"A longitudinal section of the tapering tube-end, with the screw-thread as actually formed, is shown full size in Fig.105 for a nominal 2,1/2 inch tube, that is, a tube of about 2,1/2 inches internal diameter, and 2,7/8 inches actual external diameter.

"The thread employed has an angle of 60°; it is slightly rounded off both at the top and at the bottom, so that the height or depth of the thread, instead of being exactly equal to the pitch, is only four-fifths of the pitch, or equal to $0.8\frac{1}{n}$, if n be the number of threads per inch.

Fig. 105.

(Thread of 2,1/2 inch tube. Full size.)



For the length of tube-end throughout which the screw-thread continues perfect, the empirical formula used is $(0.8\ D + 4.8) \times \frac{1}{n}$, where D is the actual external diameter of the tube throughout its parallel length, and is expressed in inches. Further back, beyond the perfect threads, come two having the same taper at the bottom, but imperfect at the top. The remaining imperfect portion of the screw-thread, furthest back from the extremity of the tube, is not essential in any way to this system of joint; and its imperfection is simply incidental to the process of cutting the thread at a single operation. From the foregoing it follows that, at the very extremity of the tube, the diameter at the bottom of the thread,

$$D - \left(\frac{2 \times (0.8\ D + 4.8)}{32n} + \frac{2 \times 0.8}{n}\right) = D - (0.05\ D + 1.9) \times \frac{1}{n}.$$

The thickness of iron below the bottom of the thread, at the tube extremity, is empirically taken to be - 0.0175 D - 0.025 Hence the actual internal diameter d of any tube is found to be, in inches,

$$d = D - (0.05 D + 1.9) \times \frac{1}{n} - 2 \times (0.0175 D + 0.025)$$

or

$$d = 0.965 D - 0.05 \frac{D}{n} - \frac{1.9}{n} - 0.05.$$

For the various sizes of tubes, ranging from 1/8 inch to 10 inches nominal internal diameter, with their corresponding numbers of screw-threads per inch, the actual internal diameter d is expressed by the following Table 1. in terms of the actual external diameter D.

TABLE 1.

DIAMETERS OF WROUGHT-IRON WELDED TUBES.

Nominal Internal Diameter of Tube	Number of Screw-threads per inch.	Actual Internal Diameter d in Terms of Actual External Diameter D.
Inches.	No.	Inches.
1/8	27	$d = 0.9631 D - 0.1204$
1/4 and 3/8	18	$d = 0.9622 D - 0.1556$
1/2 and 3/4	14	$d = 0.9614 D - 0.1857$
1, 1¼, 1,1/2 & 2	11,1/2	$d = 0.9607 D - 0.2152$
2,1/2 to 10	8	$d = 0.9587 D - 0.2875$

The figures derived from this statement, which are of importance for practical use, are presented in detail in the accompanying Table II. in a convenient order for reference.

The number of screw-threads per inch for the several sizes of tubes is here accepted from customary usage. It is the workman's approximation to the pitch practically desirable, and much reluctance must consequently be felt in calling it in question. Still it would have been better to investigate the general case upon the basis of a pitch ranging in closer accordance

with the range of tube diameter. Thus the nominal 1/2-inch tubes might have had 16 threads per inch; ¾ inch, 14 threads; 1 and 1¼ inch, 12 threads; 1,1/2 and 2 inches, 11 threads; 2,1/2 to 3,1/2 inches, 10 threads; 4 to 6 inches, 8 threads; 7 to 9 inches, 7 threads; and 10 inches, not more than 6 threads per inch. The existing numbers of threads, however, as given in Tables I. and II., are now too well established to be disturbed; at all events they must be taken in any statement of present practice.

TABLE II.

STANDARD DIMENSIONS OF WROUGHT-IRON WELDED TUBES.

DIAMETER OF TUBE.			THICKNESS OF METAL	SCREWED ENDS.	
Nominal Inside.	Actual Inside.	Actual Outside.		Number of Threads per Inch.	Length of Perfect Screw.
Inches	Inches	Inches	Inch	No.	Inch
1/8	0.270	0.405	0.068	27	0.19
1/4	0.364	0.540	0.088	18	0.29
3/8	0.494	0.675	0.091	18	0.30
1/2	0.623	0.840	0.109	14	0.39
3/4	0.824	1.050	0.113	14	0.40
1	1.048	1.315	0.134	11,1/2	0.51
1,1/4	1.380	1.660	0.140	11,1/2	0.54
1,1/2	1.610	1.900	0.145	11,1/2	0.55
2	2.067	2.375	0.154	11,1/2	0.58
2,1/2	2.468	2.875	0.204	8	0.89
3	3.067	3.500	0.217	8	0.95
3,1/2	3.548	4.000	0.226	8	1.00
4	4.026	4.500	0.237	8	1.05
4,1/2	4.508	5.000	0.246	8	1.10
5	5.045	5.563	0.259	8	1.16
6	6.065	6.625	0.280	8	1.26
7	7.023	7.625	0.301	8	1.36
8	8.982	8.625	0.322	8	1.46
9	9.000	9.688	0.344	8	1.57
10	10.019	10.750	0.366	8	1.68

Taper of conical tube-ends, 1 in 32 to axis of tube."

The above table No.II. was adopted and adhered to, until at a meeting of the Manufacturers of Wrought Iron Pipe and Boiler Tubes, held at New York in May 1889, action was taken re-

garding the outside diameter of 9" pipe, and the standard for this dimension was made 9.625 inches instead of 9.688 inches as had been recommended by Mr.Robert Briggs.

One of the most startling changes in the manufacture of butt-weld pipe occurred in 1888.

Prior to that time, all butt-weld pipe was made of wrought iron.

In 1887 a tube mill was built by the Riverside Iron Works at Wheeling, West Virginia. With this plant, as General Superintendent, was Mr.Peter Boyd, who is now General Superintendent of all of the plants of the National Tube Company.

On August 8,1888, were made the first Bessemer steel pipes ever made in this or any other country.

Other plants, after finding the pipe made by the Riverside Iron Works to be satisfactory, took up the question, and to-day about 80% of all butt-weld, as well as lap-weld pipe, is made from Bessemer steel.

This change in the material opened the argument as to the relative merits of iron and steel, which has continued throughout the nineteen years to the present date.

In 1897, Professor Henry M.Howe, an eminent authority on the metallurgy of steel, made a series of experiments for the purpose of determining the relative bursting strength, tensile strength and frictional resistance, of wrought iron and steel pipe. The following table shows the average results of the bursting pressures.

BURSTING TESTS BY HYDROSTATIC PRESSURE

	Bursting Pressure, Lbs. per Square Inch.		
	2-inch Line Pipe.	2-inch Tubing.	5,5/8-inch Casing.
Wrought iron, min.	1,000	3,300	250
" steel, "	2,300	5,150	1,450
" iron, max.	4,000	5,000	1,400
" steel, "	6,000	6,000	2,750
Wrought iron, average of all pipes tested.	2,918	4,106	931
Steel, average of all pipes tested.	4,733	5,800	2,038

The Wrought Steel Pipe did not burst at the highest available pressure, 6000 pounds per square inch.

A comparison of the average results shows that the steel pipes excelled the wrought iron pipes by 62 per cent in the line pipe, 41 per cent in the tubing, and 119 per cent in the casing.

In the tests for tensile strength, the following table gives the results.

TENSILE TESTS

	Tensile Strength, Pounds -Per Square Inch of Net Section-		
	2-Inch Line Pipe.	2-Inch Tubing.	5,5/8-Inch Casing.
Wrought iron, min.	43,107	47,244	47,312
" steel, "	63,025	60,370	75,931
" iron, max.	53,809	55,074	61,309
" steel, "	67,586	66,495	91,591
Wrought iron, average of all pipes tested.	50,002	51,852	54,311
Steel, average of all pipes tested.	65,999	63,057	82,355

The table shows that the steel pipes excelled the wrought iron pipes by the following percentages:

Line pipe----------------------32 per cent
Tubing-------------------------22 "
Casing-------------------------52 "

In the frictional tests, Professor Howe's report says, "For a given initial pressure, the final pressure is here about 6 per cent greater in case of steel than in that of wrought iron." His final conclusion is as follows,--

"To sum up, the steel pipes excel the wrought iron very greatly in bursting strength, very considerably in tensile strength, and somewhat in offering less frictional resistance to the flow of water."

The question of the relative corrosions of steel and wrought iron pipe has been thoroughly discussed at all times since the advent of steel pipe.

In 1892, Professor Henry M.Howe sums up the most trustworthy tests made up to that date with the conclusion that so far as the relative corrosion is concerned, no important difference exists between iron and steel, although the variable effect of different conditions is more marked.

In 1895, the same writer is a paper entitled "Relative Corrosion of Wrought Iron and Steel" says,

"It is misleading to say that normal low carbon steel corrodes more or that it corrodes less than wrought iron, since the relative corrosion varies with the enclosing medium. I think that we have every reason to believe that such steel, when carefully made, resists corrosion in fresh water as well as wrought iron; in cold sea water at least nearly as well as wrought iron; and in acidulated water

better than wrought iron."

At a meeting of the International Society for Testing Materials, in 1900, Professor Howe gave further data from some experiments conducted by himself, in which he exposed a number of wrought iron, soft steel and nickel steel plates, 1/8-inch thick, to the action of sea water, river water, and the weather, for two periods of one year each. The results are summed up as follows:--

	Loss by Corrosion			
	Sea Water	Fresh Water	Weather	Average
Wrought Iron	100	100	100	100
Soft Steel	114	94	103	103
3% nickel steel	83	80	67	77
25% " "	32	32	30	31

In a paper read at the annual meeting of the Canadian Mining Institute at Montreal, Canada, March 2,1905, Mr.Frank N.Speller, Metallurgical Engineer of the National Tube Company, sums up the matter as follows,--

"Increased amounts of corrosive matter in air and water, especially near the large centers of population, where the greater portion of pipe is in use, together with the complicated and far reaching action of stray currents, have materially increased the danger of corrosion during the past 10 or 15 years, since steel pipe began to be generally adopted; hence a fair comparison with pipe in use at a previous date, is clearly impossible. Yet many declaim and deplore the degeneration of present day pipe material. Fortunately, much energy is being spent in providing efficient protection for iron and steel exposed to such corrosive conditions."

Mr. Speller, later, in an article presented before the Engineers' Society of Western Pennsylvania, on November 20, 1906, besides referring to the above tests, gives the results of laboratory tests of three months' duration, in which the relative loss by corrosion was as follows,--

LOSS BY CORROSION

	Puddled Iron	Pipe Steel
Aerated Water, 180 deg. F.	100	90.6
Aerated Brine, 180 deg. F.	100	75.3
Aerated Sea Water, 180 deg. F.	100	94.2

The samples of pipe steel used in the three tests mentioned above were of "Spellerized" steel, which is being manufactured by the National Tube Company.

This process has given results which show a decided benefit to the steel, especially in the uniformity with which it corrodes. The treatment consists in a mechanical working or kneading of the metal, which tends to produce greater uniformity and improve the quality and texture of the steel.

From all definite data as submitted by the above experts, it is reasonable to presume that the contention that steel pipe is more subject to corrosion than iron pipe would be under similar conditions, is without a logical foundation.

One other objection raised by consumers against the introduction of steel pipe, was the point that it took more power to thread steel pipe than to thread iron pipe.

With the form of dies generally in use at that time, which usually corresponded to Figure 17 A, this contention was probably correct.

The National Tube Company made numerous experiments to find the correct form of cutters for threading steel pipe and finally recommended dies of the form shown in Figure 17 B, or in Figure 17 C, in which the angle Z is approximately 17 degrees.

It will be noticed that these dies also have a little clearance from the cutting edge, backward.

In January, 1906, Mr. T.N.Thompson presented a paper before the American Society of Heating and Ventilating Engineers, entitled, "Power Required to Thread, Twist, and Split Wrought Iron and Mild Steel Pipes".

As suggested by reports from the National Tube Company, he had made tests with dies of the old form and dies of the new form, threading both wrought iron and steel pipe. The results are tabulated below,--

	Old Form of Die	New Form of Die
Kind of Pipe	Pull in Pounds on a 21 inch Lever.	Pull in Pounds on a 21 inch Lever.
1,1/4 inch wrought iron	83 to 87 lbs. pull.	58 to 62 lbs. pull.
1,1/4 inch mild steel	100 to 111 " "	60 to 65 " "

"It shows that the power required to thread mild steel pipe with the new die is not much more than that required to thread wrought iron pipe with the same die, and much less than the power required to thread wrought iron pipe with the common die."

Mr.Thompson also made tests to determine the relative power required to twist and split wrought iron pipe and mild steel pipe. His summary is given below,--

APPROXIMATE POWER REQUIRED (POUNDS) TO THREAD, TWIST AND SPLIT PIPE.

SUMMARY

Kind of pipe.	To Thread; well oiled; steady pull at 16 inch leverage on die-stock arm.			To Twist.	To Split.	Margin of safety. Lbs.
	New rake dies. Lbs.	New common dies. Lbs.	Old common dies. Lbs.	Steady pull with stillson's Lbs.	Steady pull with stillson's Lbs.	
1/2" Steel (4 samples)	34.5	56.25	60.5	122.5	152.5	73.85
1/2" Iron (7 samples)	27.14	33.14	49.14	102.14	110.	46.12
3/4" Steel (4 samples)	44.25	60.5	90.75	150.	240.	122.05
3/4" Iron (8 samples)	44.375	51.25	73.5	140.	176.43	80.88
1" Steel (5 samples)	68.8	111.	124.	286.	420.	258.8
1" Iron (7 samples)	62.14	105.7	118.57	272.85	326.66	172.52

An examination of this table shows the greater amount of power required to twist steel pipe, the greater amount of power required to split steel pipe and also the larger margin of safety between the twisting and splitting loads of steel pipe.

This result coincides with tests made by the National Tube Company of the transverse tensile strengths of the solid metal of the pipe and of the weld of the pipe, the results of which are given below:--

	Pulled in Metal Pounds Per Square Inch	Pulled at Weld Pounds Per Square Inch
Iron	34520	24540
Steel	61850	46080

From the above figures it will be seen that the strength of the weld is nearly twice as great in the case of the steel

pipe as it is in the case of the iron pipe.

In Table 2 are given the dimensions of standard, extra strong and double extra strong pipe. Three inch pipe and smaller are butt welded, above three inch lap welded.

The weights, thicknesses, and internal diameters are "card dimensions". In ordinary merchant, standard pipe, it will be found that the weight per foot is somewhat less, and consequently the thickness somewhat less and the internal diameter somewhat more. This has come about from the fact that as the processes of manufacture became improved, it was not necessary to use material as thick as was formerly used in order to secure a perfect and sufficiently strong pipe for standard pressures.

It will be noted that the thickness of extra strong pipe is approximately 1.4; that of standard pipe and double extra strong is 2.8 times the thickness of standard pipe.

Table 3 also gives the various dimensions of the threads of all sizes of pipe, up to and including 12 inches.

These dimensions conform to the Briggs' standard.

Tables 4 and 5 show the dimensions of sockets, or couplings.

In order that the reader may have a definite idea of the steps in the manufacture of a butt weld pipe from the strip of skelp to the finished pipe, the following brief description is given:--

The strips as received from the rolling mill are about twenty feet long and of the requisite width and thickness to make the desired size of pipe. For instance: the strip for one inch pipe is about 4,1/8 inches wide and .134 inches thick.

The strips are delivered back of the welding furnace, which is of the Siemens type, of the general style as shown by figure number 18.

The front end of each strip has been clipped on an angle of about 60 degrees, leaving the front end about one-third of the original width, as shown in figure 16.

This clipped end has also been cupped longitudinally so that as the skelp strikes the bell it will always curve in the same direction, downward.

A load of these strips is placed on the charger and one by one these are shoved into the furnace, working from left to right and keeping from five to fourteen strips always in the furnace, according to the size of the furnace and the width of the strips being charged.

As soon as shoved in, either by the charger or by two men, another man, the "picker", with a long forked-end bar, engages the back end of the strip and places it in its correct position, free from contact with other strips and with the front end of the strip within easy reaching distance of the welder at the front end of the furnace.

At the front or drawing end of the furnace, is the welder. At his side is a rack containing a number of pipe drawing tongs. When the skelp is at nearly a welding heat, the welder takes a pair of tongs, grasps the end of the skelp with them, closes the tongs, slips a bell or two bells over the tongs, and drops the reins of the tongs into the slot in the top of the bell holder, which is at the front end of the drawbench.

The bench is swung back and forth across the furnace so

that the bell holder may come into line with the skelp which is to be drawn.

After the reins of the tongs are dropped through the slot in the bell holder, the "hook runner" engages the knob on the end of the rein with the forked end of his hook, (see figure 13) and forces the hook down into engagement with the draw bench chain, which is positively driven from the end farthest away from the furnace.

The tong with the skelp is dragged along by the hook, the bell is stopped by the bell holder, the skelp coming in contact with the bell is curved across its width and the longitudinal edges meeting are butted together, the pressure welding them together and thus forming the pipe.

After the last end of the pipe has passed through the bell, the hook is disengaged from the tong by the hook runner, who has followed the hook along the bench, and the hook runner returns to the furnace to hook up another pair of tongs which the welder has fastened to the next heated strip of skelp.

A man at the end of the drawbench farthest from the furnace, takes hold of the tong as the hook runner releases it from the hook, opens it, disengages it from the pipe, and places the tong with the hot jaws in a bosh of cold water. From there the tongs are returned to the welder's rack, either by a man or in some instances by a tong carrier.

In one plant the tong carrier is attached directly to the drawbench.

On the opposite side of the bench from the welder stands the "first pass" man, who, as soon as the tong has been taken

from the hot pipe, grasps the other end with a pair of tongs and shoves the pipe into the first pair of sizing rolls.

These rolls are from 14 inches to 18 inches in diameter and are positively driven either by a motor or by connection with the engine shaft. After passing through these rolls, which round up the pipe and reduce it slightly in diameter, the pipe passes through another set of sizing rolls, or a set of cross rolls, as previously described.

Then it passes onto a rack which is somewhat longer than the pipe. Moving up this rack are link belt chains with vertical attachment links.

These attachments move the pipe upward across the rack. The pipe naturally rolls, and as these attachments are kept in line with each other, the pipe is kept straight and any bend is rolled out, so that by the time the pipe reaches the top of the rack and rolls onto a car or truck, it is very straight.

The rough ends are next cut off, either by a tool held in a tool post, by a rotary pipe cutter, or by hot saws, the latter method seeming to grow in favor recently.

A thread is then cut on each end, a socket is screwed on, the pipe is submitted to a hydraulic bursting test of from 600 to 1500 pounds per square inch, the former pressure being the test for merchant pipe and the latter for line pipe.

The pipe is then inspected for bad threads, surface imperfections, etc., is measured, bundled, a tin tag showing the number of feet in the bundle is attached, and the pipe is ready for shipment.

With the development of motor driven machinery and tools

the pipe mills have kept pace, and now all of the machinery in modern pipe mills is driven by individual motors.

High speed tool steels are being used successfully in cutting threads on pipe, and pipe mill machinery and processes are, as in all other lines, improving constantly.

The general method,however, is like that outlined above.

Just preceding the drawings are bound two photographs. The first shows the charging end of one of the forty-foot furnaces at the Lorain plant of the National Tube Company. Among the details clearly shown are the overhead crane, lifting arms for skelp, charging machine, the rear end of the furnace, the man who is the "picker" and the man who places the sheets in the trough of the charger. The rear end of the charger,together with the charger operator and his controller levers,is not shown.

The second photograph shows the front end of the furnace, the welder, a pipe being drawn, the hook runner, the drawbench, the hot pipe conveyor, and the disc saw which divides the forty-foot pipe into two lengths each twenty feet long. The ventilating fan which blows on the welder in hot weather is also plainly shown.

The writer is indebted to Mr.F.N.Speller, Metallurgical Engineer of the National Tube Company, for these photographs.

In the preparation of this thesis, the writer has endeavored to give a comprehensive review of all of the books and periodical literature pertaining to the subject, together with such facts as have come to his attention in his practical experience in the manufacture of butt-weld pipe.

Among the books and articles consulted were the following, some of which have already been mentioned,---

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"Pipes and Tubes" by P.R.Bjorling, London,1902.

"Steam Pipes" by W.H.Booth, New York, 1906.

"Hand Book of The National Tube Company". Published in Pittsburgh in 1902 and edited by Prof.Reid T.Stewart.

"Dimensions of Pipe, Fittings and Valves" by W.D.Browning,Cleveland, Ohio, 1905.

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------oOo------

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"The Manufacture of Wrought-Iron Pipe", Scientific American Supplement,August 10,1878.

"Wrought Iron Pipe" by Hamilton Smith, read before Iron and Steel Institute, London, published in Scientific American Supplement June 26,1886.

"Report of the Committee on Standard Pipe and Pipe Threads" of the American Society of Mechanical Engineers, submitted at the Seventh Annual Meeting,held in New York City, November 29 to December 3, 1886, and published in Volume 8 of the Transactions.

"Early History of Wrought-Iron Gas Pipe" by R.T.Crane, The Engineering Record, July 8,1893.

"Standard Sizes of Wrought Iron Pipe for Steam, Water and Gas", The Locomotive, September,1896.

"The Relative Strength of Wrought Iron and Steel Pipe", by Prof. Henry M.Howe, American Manufacturer and Iron World, April 29,1898.

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"British Pipe Threads" by W.H.Booth,American Machinist,July 27,1905.

"British Standard Pipe Threads, for Iron or Steel Pipes and Tubes", report issued by The Engineering Standards Committee, published by Crosby Lockwood & Son, London, April, 1905.

"Steel and Iron Wrought Pipe" by Frank N.Speller,read at the Annual Meeting of the Canadian Mining Institute at Montreal,Canada,March 2,1905.

"Power Required to Thread,Twist and Split Wrought Iron and Mild Steel Pipes" by T.N.Thompson,read before American Society of Heating and Ventilating Engineers, January, 1906.

"The Manufacture of Welded Pipe" by Victor Beutner, Proceedings of the Engineers Society of Western Pennsylvania, Volume 19,Pages 796 to 834.

"The Corrosion of Pipe in Coal Mines", The Iron Age,July 12,1906.

"Collapsing Pressures of Bessemer Steel Lap Welded Tubes" by Prof. R.T.Stewart,Volume XXVII, Transactions of American Society of Mechanical Engineers.

"Resistance of Tubes to Collapse" by Prof.A.P.Carman,Bulletin No.5 of the University of Illinois Engineering Experiment Station, June 1,1906.

"Wrought Iron Pipe vs Steel Pipe", Reading Iron Company,April,1906.
"Materials and Properties of Wrought Pipe" by F.N.Speller,read before Engineers Society of Western Pennsylvania,Nov.20,1906; Volume XXII, No.10 of the Proceedings,January,1907.

NATIONAL TUBE CO.—Black or Galvanized Standard Weight Pipe.

DIAMETER.			Thickness.	CIRCUMFERENCE.		TRANSVERSE AREAS.			Nom. Wgt. per ft. lbs.	Threads per In.
Nom.	External.	Internal.		External.	Internal.	External.	Internal.	Metal.		
⅛	.405	.269	.068	1.272	.845	.1288	.0568	.0720	.241	27
¼	.540	.364	.088	1.696	1.144	.2290	.1041	.1249	.42	18
⅜	.675	.493	.091	2.121	1.549	.3578	.1909	.1669	.559	18
½	.840	.622	.109	2.639	1.954	.5542	.3039	.2503	.837	14
¾	1.050	.824	.113	3.299	2.589	.8659	.5333	.3326	1.115	14
1	1.315	1.047	.134	4.131	3.289	1.3581	.8609	.4972	1.668	11½
1¼	1.660	1.380	.140	5.215	4.335	2.1642	1.4957	.6685	2.244	11½
1½	1.900	1.610	.145	5.969	5.058	2.8353	2.0358	.7995	2.678	11½
2	2.375	2.067	.154	7.461	6.494	4.4301	3.3556	1.074	3.609	11½
2½	2.875	2.467	.204	9.032	7.750	6.4918	4.7800	1.712	5.739	8
3	3.500	3.066	.217	10.996	9.632	9.6211	7.3827	2.238	7.536	"
3½	4.000	3.548	.226	12.566	11.146	12.566	9.886	2.680	9.001	"
4	4.500	4.026	.237	14.137	12.648	15.904	12.730	3.174	10.665	"
4½	5.000	4.508	.246	15.708	14.162	19.635	15.960	3.675	12.34	"
5	5.563	5.045	.259	17.477	15.849	24.306	19.985	4.321	14.502	"
6	6.625	6.065	.280	20.813	19.054	34.472	28.886	5.586	18.762	"
7	7.625	7.023	.301	23.955	22.063	45.664	38.743	6.921	23.271	"
8	8.625	7.981	.322	27.096	25.073	58.426	50.021	8.405	28.177	"
9	9.625	8.937	.344	30.238	28.076	72.760	62.722	10.04	33.701	"
10	19.750	10.018	.366	33.772	31.472	90.763	78.822	11.94	40.065	"
11	11.750	11.000	.375	36.913	34.558	108.43	95.034	13.40	45.95	"
12	12.750	12.000	.375	40.055	37.699	127.68	113.09	14.59	48.985	"

Allow variation in weight per foot of 5 per cent. above and 5 per cent. below. Cannot cut closer to length than 1/16 inch. Shipped threads and couplings unless otherwise ordered

NATIONAL TUBE CO.—Standard Extra Strong Pipe.

DIAMETER.			Thickness.	CIRCUMFERENCE.		TRANSVERSE AREAS.			Nom. Wgt. per ft. lbs.	Threads per In.
Nom.	External.	Internal.		External.	Internal.	External.	Internal.	Metal.		
⅛	.405	.205	.100	1.272	.644	.129	.033	.096	.29	27
¼	.540	.294	.123	1.696	.924	.229	.068	.161	.54	18
⅜	.675	.421	.127	2.121	1.323	.358	.139	.219	.74	18
½	.840	.542	.149	2.639	1.703	.554	.231	.323	1.09	14
¾	1.050	.736	.157	3.299	2.312	.866	.425	.441	1.39	14
1	1.315	.951	.182	4.131	2.988	1.358	.710	.648	2.17	11½
1¼	1.660	1.272	.194	5.215	3.996	2.164	1.271	.893	3.00	11½
1½	1.900	1.494	.203	5.969	4.694	2.835	1.753	1.082	3.63	11½
2	2.375	1.933	.221	7.461	6.073	4.430	2.935	1.495	5.02	11½
2½	2.875	2.315	.280	9.032	7.973	6.492	4.209	2.283	7.67	8
3	3.500	2.892	.304	10.996	9.086	9.621	6.569	3.052	10.25	"
3½	4.000	3.358	.321	12.566	10.549	12.566	8.856	8.710	12.47	"
4	4.500	3.818	.341	14.137	11.995	15.904	11.449	4.455	14.97	"
4½	5.000	4.280	.360	15.708	13.446	19.635	14.387	5.248	18.22	"
5	5.563	4.813	.375	17.477	15.120	24.306	18.193	6.113	20.54	"
6	6.625	5.751	.437	20.813	18.067	34.472	25.976	8.496	28.58	"
7	7.625	6.625	.500	23.955	20.813	45.664	34.472	11.192	37.67	"
8	8.625	7.625	.500	27.096	23.955	58.426	45.664	12.762	43.00	"
9	9.625	8.625	.500	30.238	27.096	72.760	58.426	14.334	48.25	"
10	10.750	9.750	.500	33.772	30.631	90.763	74.662	16.101	54.25	"
12	12.750	11.750	.500	40.055	36.914	127.68	108.43	19.25	65.00	"

NATIONAL TUBE CO.—Standard Double Extra Strong Pipe.

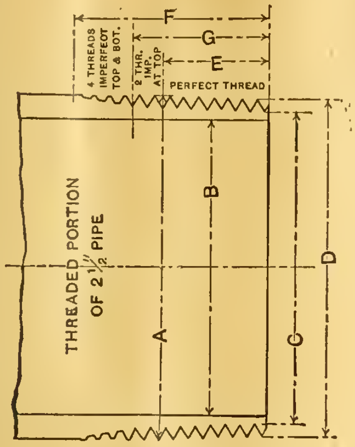
DIAMETER.			Thickness.	CIRCUMFERENCE		TRANSVERSE AREAS.			Nom. Wgt. per ft. lbs.	Threads per In.
Nom.	External.	Internal.		External.	Internal.	External.	Internal.	Metal Area		
½	.840	.244	.298	2.639	.767	.554	.047	.507	1.7	14
¾	1.050	.422	.314	3.299	1.326	.866	.140	.726	2.44	14
1	1.315	.587	.364	4.131	1.844	1.358	.271	1.087	3.65	11½
1¼	1.660	.885	.388	5.215	2.780	2.164	.615	1.549	5.2	11½
1½	1.900	1.088	.406	5.969	3.418	2.835	.930	1.905	6.4	11½
2	2.375	1.491	.442	7.461	4.684	4.430	1.744	2.686	9.02	11½
2½	2.875	1.755	.560	9.032	5.514	6.492	2.419	4.073	13.68	8
3	3.500	2.284	.608	10.996	7.176	9.621	4.097	5.524	18.56	"
3½	4.000	2.716	.642	12.566	8.533	12.566	5.794	6.772	22.75	"
4	4.500	3.136	.682	14.137	9.852	15.904	7.724	8.180	27.48	"
4½	5.000	3.564	.718	15.708	11.197	19.635	9.976	9.659	32.53	"
5	5.563	4.063	750	17.477	12.764	24.306	12.965	11.341	38.12	"
6	6.625	4.875	.875	20.813	15.315	34.472	18.365	15.807	53.11	"
7	7.625	5.875	.875	23.955	18.457	45.664	27.109	18.555	62.38	"
8	8.625	6.875	.875	27.096	21.598	58.426	37.122	21.304	71.62	"

Supplement to the Draftsman, July 1904.

·TABLE · 2·

Contributed.

STANDARD PIPE AND PIPE THREADS.



A = outside diameter of perfect thread.
B = inside diameter of pipe.
C = root diameter of thread at end of pipe.
D = outside diameter of thread at end of pipe.
E = length of perfect thread.
F = total length of thread.
G = length of perfect thread plus two threads.

Briggs' Formula.

E = perfect thread $= (4.8 + 0.8\,A)\,P.$

P = pitch of thread $= \dfrac{1}{N}.$

N = number of threads.
F = length of taper at top.
Taper ¾" to one foot.

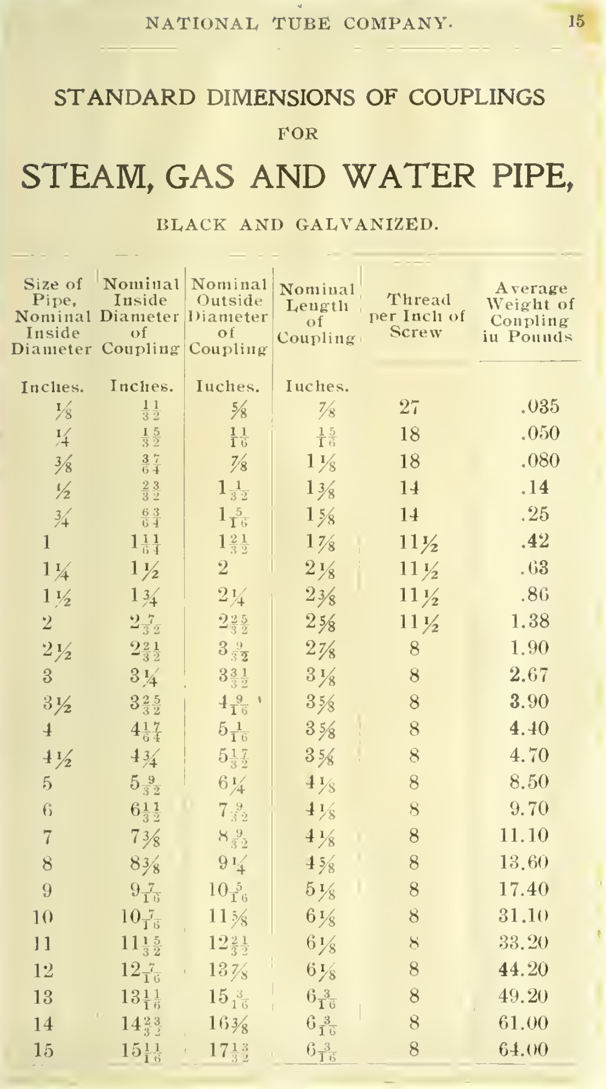
Height of thread $= 8\,\dfrac{1}{N}.$

G = length of taper at bottom.

Size.	Thread.	A	B	C	D	E	F	G
⅛	27	.405	.270	.334	.393	.19	.41	.264
¼	18	.540	.364	.433	.522	.29	.62	.402
⅜	18	.675	.494	.567	.656	.30	.63	.408
½	14	.840	.623	.702	.816	.39	.82	.534
¾	14	1.050	.824	.911	1.025	.40	.83	.546
1	11½	1.315	1.048	1.144	1.283	.51	1.03	.683
1¼	11½	1.660	1.380	1.488	1.627	.54	1.06	.707
1½	11½	1.900	1.611	1.727	1.866	.55	1.07	.724
2	11½	2.375	2.067	2.200	2.339	.58	1.10	.757
2½	8	2.875	2.468	2.618	2.818	.89	1.64	1.138
3	8	3.500	3.067	3.243	3.443	.95	1.70	1.200
3½	8	4.000	3.548	3.738	3.938	1.00	1.75	1.250
4	8	4.500	4.026	4.233	4.443	1.05	1.80	1.300
4½	8	5.000	4.508	4.733	4.933	1.10	1.85	1.350
5	8	5.663	5.045	5.289	5.489	1.16	1.91	1.406
6	8	6.625	6.065	6.347	6.547	1.26	2.01	1.513
7	8	7.625	7.023	7.340	7.540	1.36	2.11	1.612
8	8	8.625	7.981	8.332	8.532	1.46	2.21	1.712
9	8	9.625	8.937	9.324	9.524	1.56	2.31	1.812
10	8	10.750	10.019	10.445	10.645	1.675	2.425	1.925
11	8	12.000	11.224	11.694	11.894	1.80	2.55	2.050
12	8	13.000	12.180	12.685	12.885	1.90	2.65	2.150

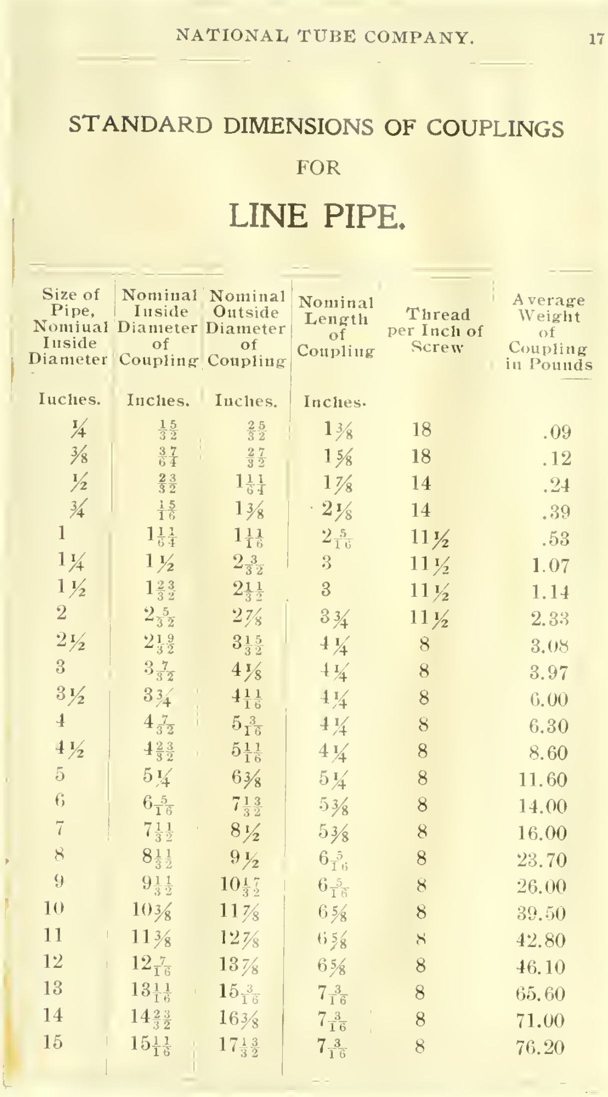
No. 40, Supplement to MACHINERY, January, 1906.

·TABLE·3·



STANDARD DIMENSIONS OF COUPLINGS
FOR
STEAM, GAS AND WATER PIPE,
BLACK AND GALVANIZED.

Size of Pipe, Nominal Inside Diameter	Nominal Inside Diameter of Coupling	Nominal Outside Diameter of Coupling	Nominal Length of Coupling	Thread per Inch of Screw	Average Weight of Coupling in Pounds
Inches.	Inches.	Inches.	Inches.		
1/8	11/32	5/8	7/8	27	.035
1/4	15/32	11/16	15/16	18	.050
3/8	37/64	7/8	1 1/8	18	.080
1/2	23/32	1 1/32	1 3/8	14	.14
3/4	63/64	1 5/16	1 5/8	14	.25
1	1 11/64	1 21/32	1 7/8	11 1/2	.42
1 1/4	1 1/2	2	2 1/8	11 1/2	.63
1 1/2	1 3/4	2 1/4	2 3/8	11 1/2	.86
2	2 7/32	2 25/32	2 5/8	11 1/2	1.38
2 1/2	2 21/32	3 9/32	2 7/8	8	1.90
3	3 1/4	3 31/32	3 1/8	8	2.67
3 1/2	3 25/32	4 9/16	3 5/8	8	3.90
4	4 17/64	5 1/16	3 5/8	8	4.40
4 1/2	4 3/4	5 17/32	3 5/8	8	4.70
5	5 9/32	6 1/4	4 1/8	8	8.50
6	6 11/32	7 9/32	4 1/8	8	9.70
7	7 3/8	8 9/32	4 1/8	8	11.10
8	8 3/8	9 1/4	4 5/8	8	13.60
9	9 7/16	10 5/16	5 1/8	8	17.40
10	10 7/16	11 5/8	6 1/8	8	31.10
11	11 15/32	12 21/32	6 1/8	8	33.20
12	12 7/16	13 7/8	6 1/8	8	44.20
13	13 11/16	15 3/16	6 3/16	8	49.20
14	14 23/32	16 3/8	6 3/16	8	61.00
15	15 11/16	17 13/32	6 3/16	8	64.00



STANDARD DIMENSIONS OF COUPLINGS
FOR
LINE PIPE.

Size of Pipe, Nominal Inside Diameter	Nominal Inside Diameter of Coupling	Nominal Outside Diameter of Coupling	Nominal Length of Coupling	Thread per Inch of Screw	Average Weight of Coupling in Pounds
Inches.	Inches.	Inches.	Inches.		
1/4	15/32	25/32	1 3/8	18	.09
3/8	37/64	27/32	1 5/8	18	.12
1/2	23/32	1 11/64	1 7/8	14	.24
3/4	15/16	1 3/8	2 1/8	14	.39
1	1 11/64	1 11/16	2 5/16	11 1/2	.53
1 1/4	1 1/2	2 3/32	3	11 1/2	1.07
1 1/2	1 23/32	2 11/32	3	11 1/2	1.14
2	2 5/32	2 7/8	3 3/4	11 1/2	2.33
2 1/2	2 19/32	3 15/32	4 1/4	8	3.08
3	3 7/32	4 1/8	4 1/4	8	3.97
3 1/2	3 3/4	4 11/16	4 1/4	8	6.00
4	4 7/32	5 3/16	4 1/4	8	6.30
4 1/2	4 23/32	5 11/16	4 1/4	8	8.60
5	5 1/4	6 3/8	5 1/4	8	11.60
6	6 5/16	7 13/32	5 3/8	8	14.00
7	7 11/32	8 1/2	5 3/8	8	16.00
8	8 11/32	9 1/2	6 5/16	8	23.70
9	9 11/32	10 17/32	6 5/16	8	26.00
10	10 3/8	11 7/8	6 5/8	8	39.50
11	11 3/8	12 7/8	6 5/8	8	42.80
12	12 7/16	13 7/8	6 5/8	8	46.10
13	13 11/16	15 3/16	7 3/16	8	65.60
14	14 23/32	16 3/8	7 3/16	8	71.00
15	15 11/16	17 13/32	7 3/16	8	76.20

· TABLE · 4 ·

STANDARD DIMENSIONS OF COUPLINGS FOR

DRIVE PIPE.

Size of Pipe, Nominal Inside Diameter	Nominal Inside Diameter of Coupling	Nominal Outside Diameter of Coupling	Nominal Length of Coupling	Thread per Inch of Screw	Average Weight of Coupling in Pounds
Inches.	Inches.	Inches.	Inches.		
1¼	1½	2 3/32	2⅞	11½	1.07
1½	1¾	2 11/32	2⅞	11½	1.15
2	1 3/16	2⅞	3 11/16	11½	2.53
2½	2⅝	3 15/32	4⅛	8	3.40
3	3¼	4 5/32	4⅛	8	3.88
3½	3 25/32	4 23/32	4 3/16	8	6.12
4	4¼	5¼	4 3/16	8	6.30
4½	4¾	5 11/16	4 3/16	8	7.00
5	5 17/64	6 7/16	5 3/16	8	8.50
6	6 5/16	7 7/16	5 3/16	8	13.10
7	7 11/32	8½	5 3/16	8	15.50
8	8 11/32	9½	6⅛	8	23.30
9	9 11/32	10 17/32	6⅛	8	25.20
10	10⅜	11⅞	6⅝	8	39.50
11	11⅜	12⅞	6⅝	8	42.80
12	12 7/16	13⅞	6⅝	8	46.10
13	13 11/16	15 3/16	7⅛	8	68.00
14	14 23/32	16⅜	7⅛	8	71.00
15	15 11/16	17⅜	7⅛	8	76.20

STANDARD DIMENSIONS OF COUPLINGS FOR

TUBING.

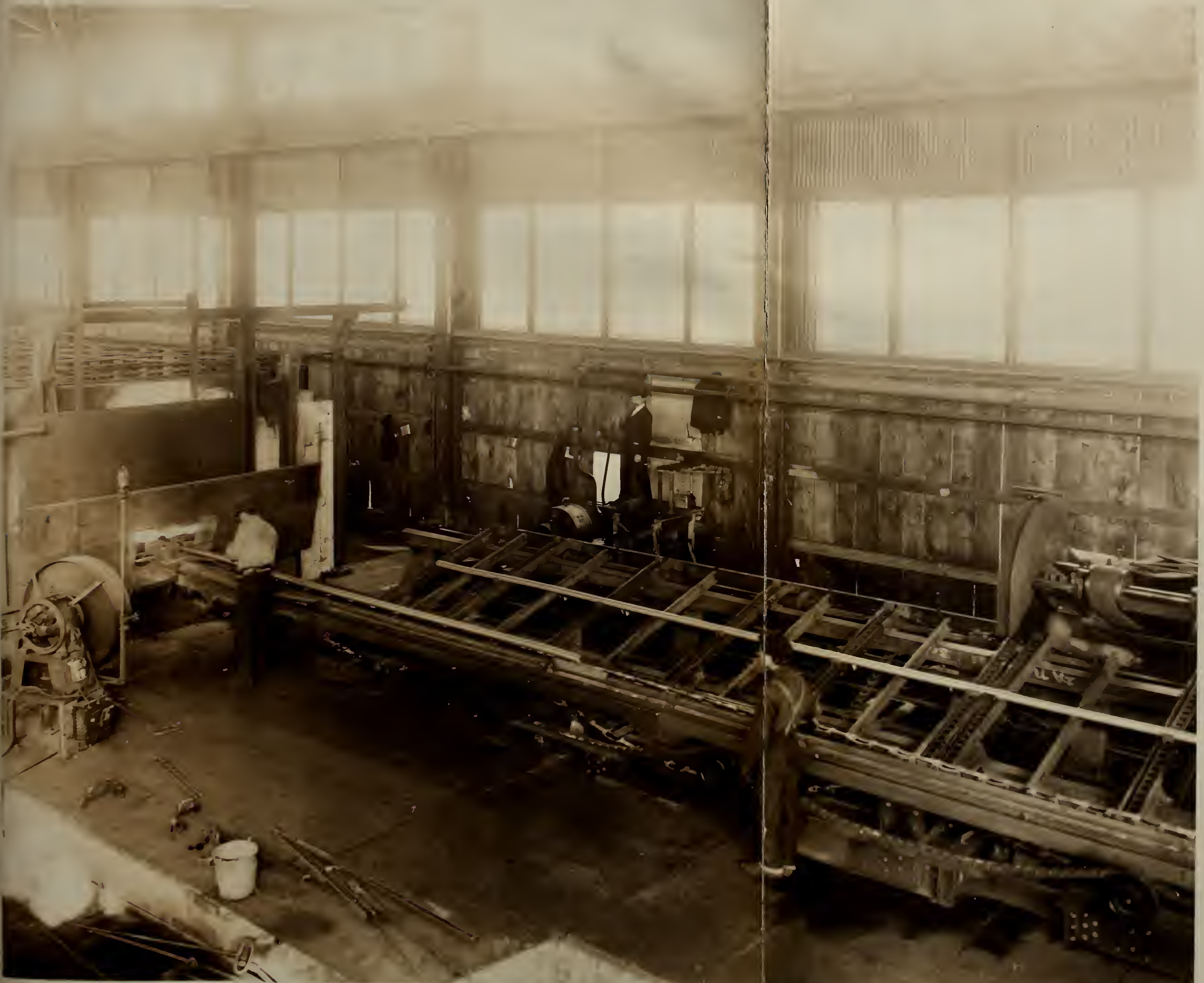
Size of Tubing, Nominal Inside Diameter	Nominal Inside Diameter of Coupling	Nominal Outside Diameter of Coupling	Nominal Length of Coupling	Thread per Inch of Screw	Average Weight of Coupling in Pounds
Inches.	Inches.	Inches.	Inches.		
1¼	1½	2 3/32	2 15/16	11½	1.07
1½	1 23/32	2 11/32	2 15/16	11½	1.14
2	2 5/32	2⅞	3 11/16	11½	2.33
2½	2 19/32	3½	4⅛	11½	3.14
3	3 7/32	4 5/32	4⅛	11½	3.99
3½	3¾	4 11/16	4⅛	8	6.00
4	4 7/32	5 3/16	4⅛	8	6.30
4½	4 23/32	5 11/16	4⅛	8	8.60
5	5¼	6⅜	5⅛	8	11.60
6	6 5/16	7 13/32	5 3/16	8	14.00

STANDARD DIMENSIONS OF COUPLINGS FOR

REGULAR CASING.

Size of Casing, Nominal Inside Diameter	Nominal Inside Diameter of Coupling	Nominal Outside Diameter of Coupling	Nominal Length of Coupling	Thread per Inch of Screw	Average Weight of Coupling in Pounds
Inches.	Inches.	Inches.	Inches.		
1¾	1⅞	2 13/32	2 5/16	14	.93
2	2 7/64	2¾	2¾	14	1.20
2¼	2 11/32	2 31/32	2¾	14	1.62
2½	2 19/32	3¼	3	14	1.66
2¾	2 27/32	3 15/32	3	14	2.00
3	3 3/32	3¾	3 3/16	14	2.42
3¼	3 11/32	4 1/32	3 3/16	14	2.50
3½	3 19/32	4 7/32	3 3/16	14	2.66
3¾	3 27/32	4½	3 3/16	14	2.90
4	4 1/16	4 11/16	3⅝	14	3.71
4¼	4⅜	5	3⅝	14	3.949
4½	4 19/32	5 7/32	3⅝	14	4.156
4¾	4 13/16	5½	3⅝	14	4.726
5	5 5/64	5 25/32	4⅛	14 & 11½	5.146
5 3/16	5 5/16	6 1/64	4⅛	14 & 11½	5.936
5⅝	5 55/64	6 19/32	4⅛	14 & 11½	7.480
6¼	6 13/32	7 9/32	4⅛	14 & 11½	8.40
6⅝	6 51/64	7⅝	4⅝	14 & 11½	9.30
7¼	7 15/32	8 5/16	4⅝	14 & 11½	11.60
7⅝	7 25/32	8 13/16	5⅛	11½	14.60
8¼	8 13/32	9 13/32	5⅛	11½	16.40
8⅝	8 25/32	9 13/16	5⅛	11½	16.60
9⅝	9¾	10 27/32	6⅛	11½	23.70
10¼	10½	11½	6⅛	11½	25.10
10⅝	10 25/32	11 27/32	6⅛	11½	28.00
11⅝	11 25/32	12 29/32	6⅛	11½	29.40
12½	12 25/32	14	6⅛	11½	38.40
13½	13 25/32	15 1/32	6⅛	11½	40.20
14½	14¾	16 5/32	6⅛	11½	58.00
15½	15¾	17¼	6 3/16	11½	60.00

·TABLE·5·



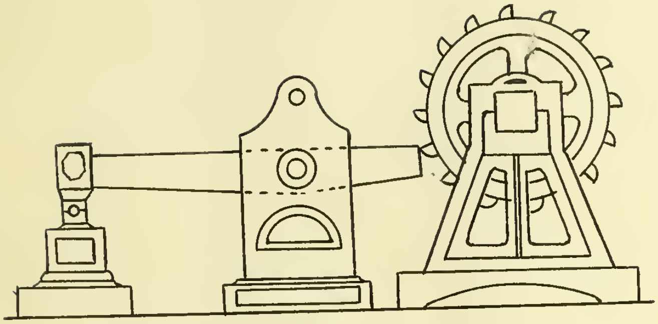


FIG. 1.

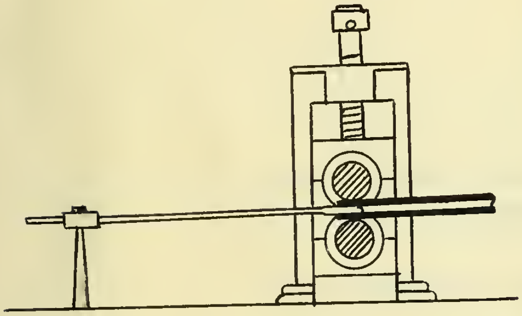


FIG. 2.

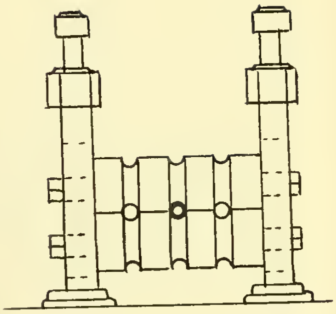


FIG. 3.

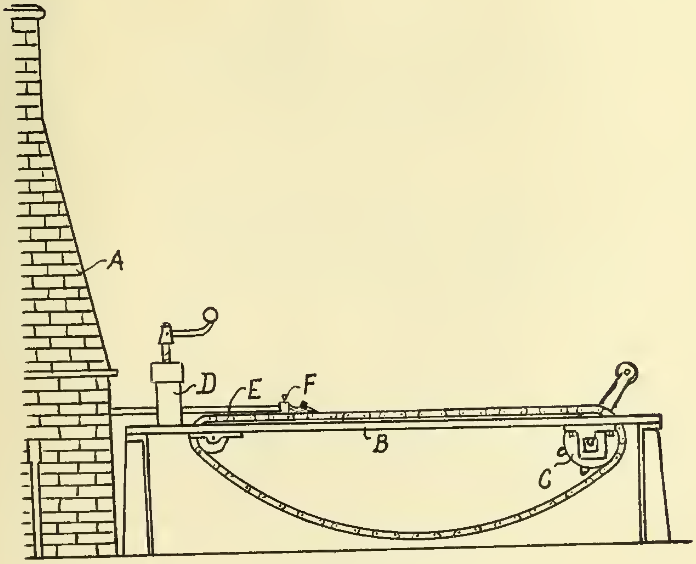


FIG. 4.

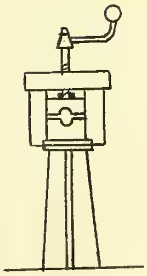
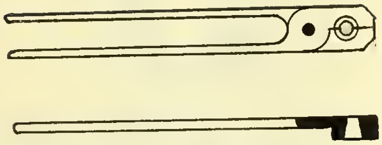
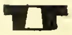


FIG. 5.



FIG·7·



FIG·6·

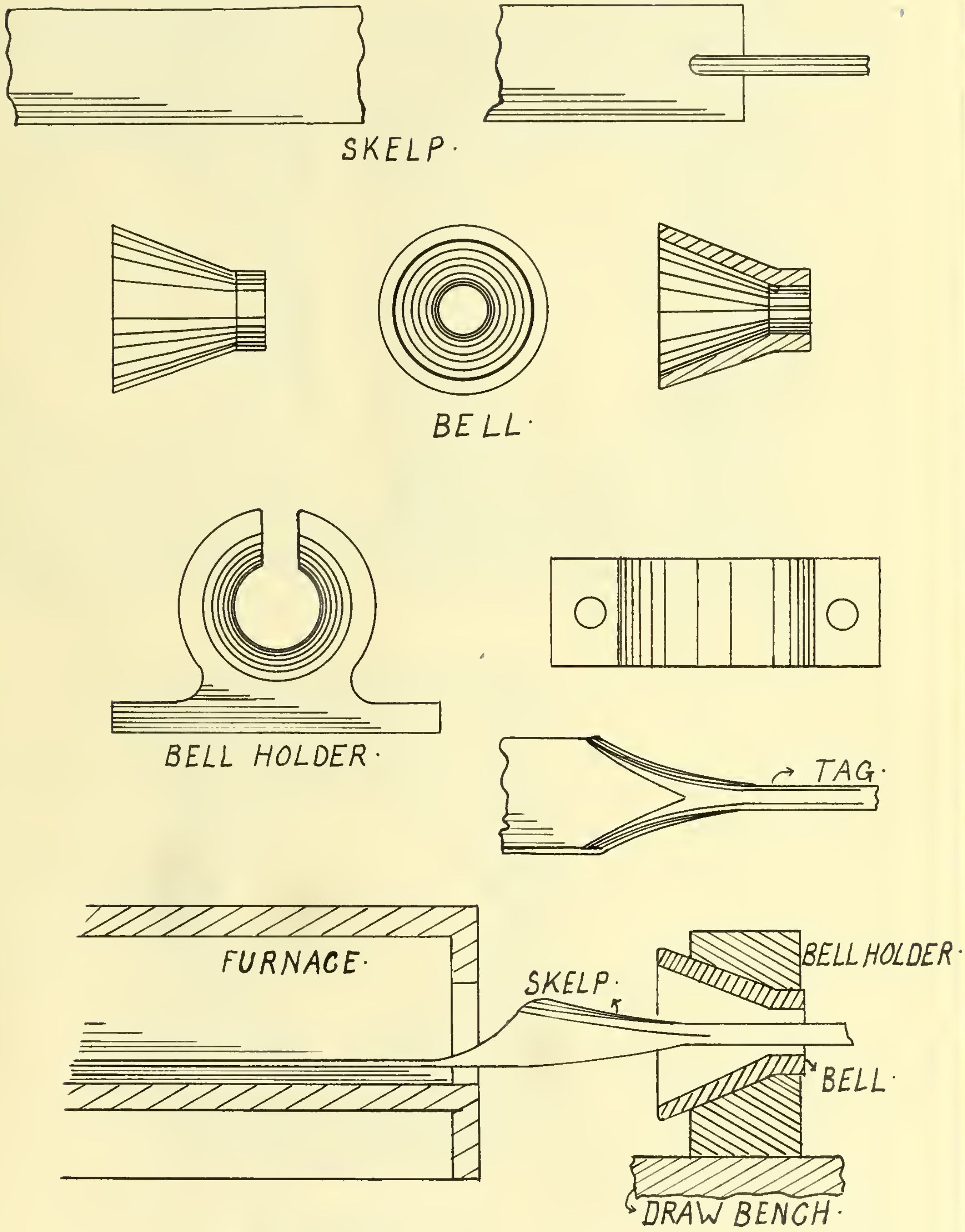
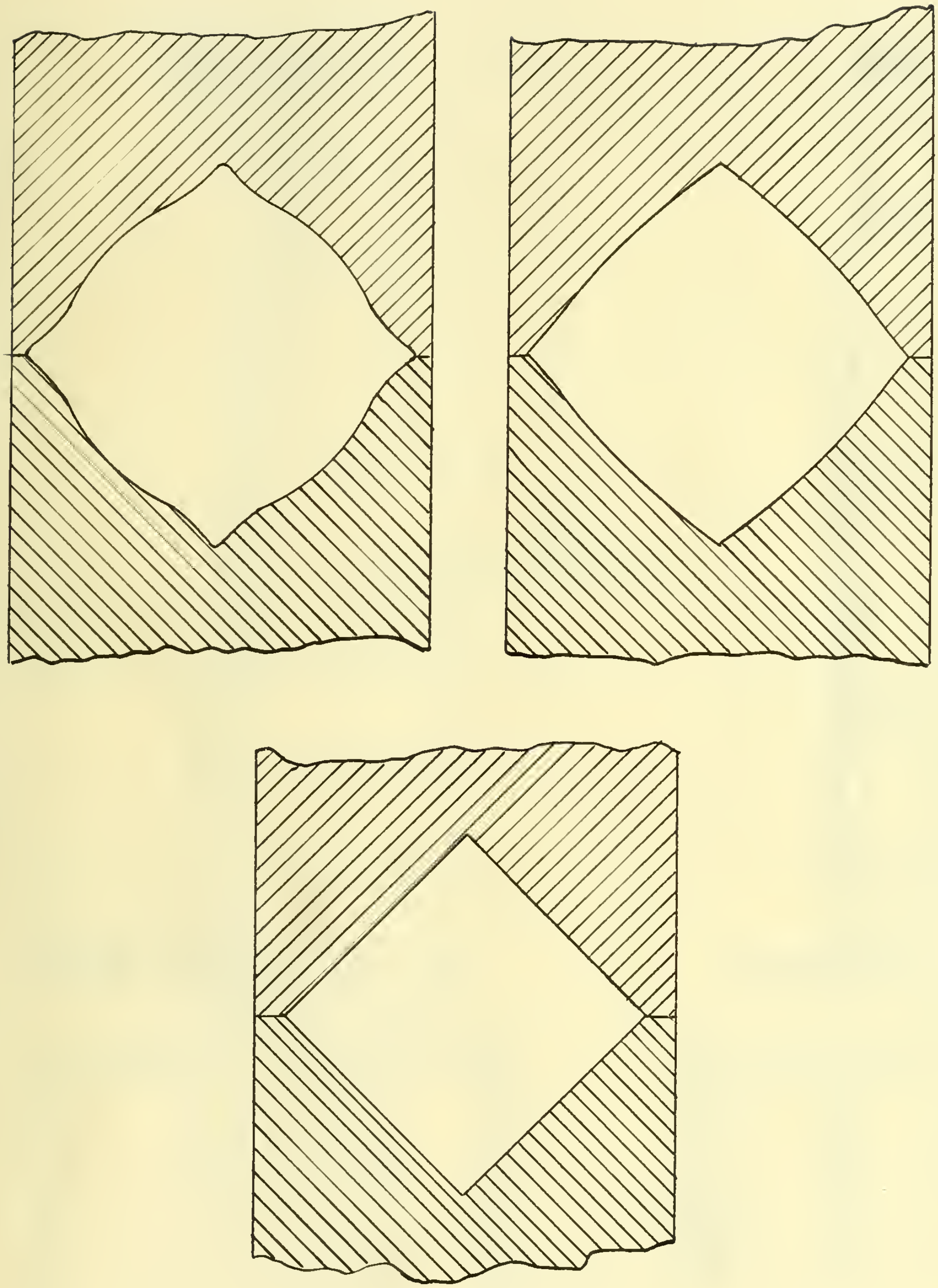
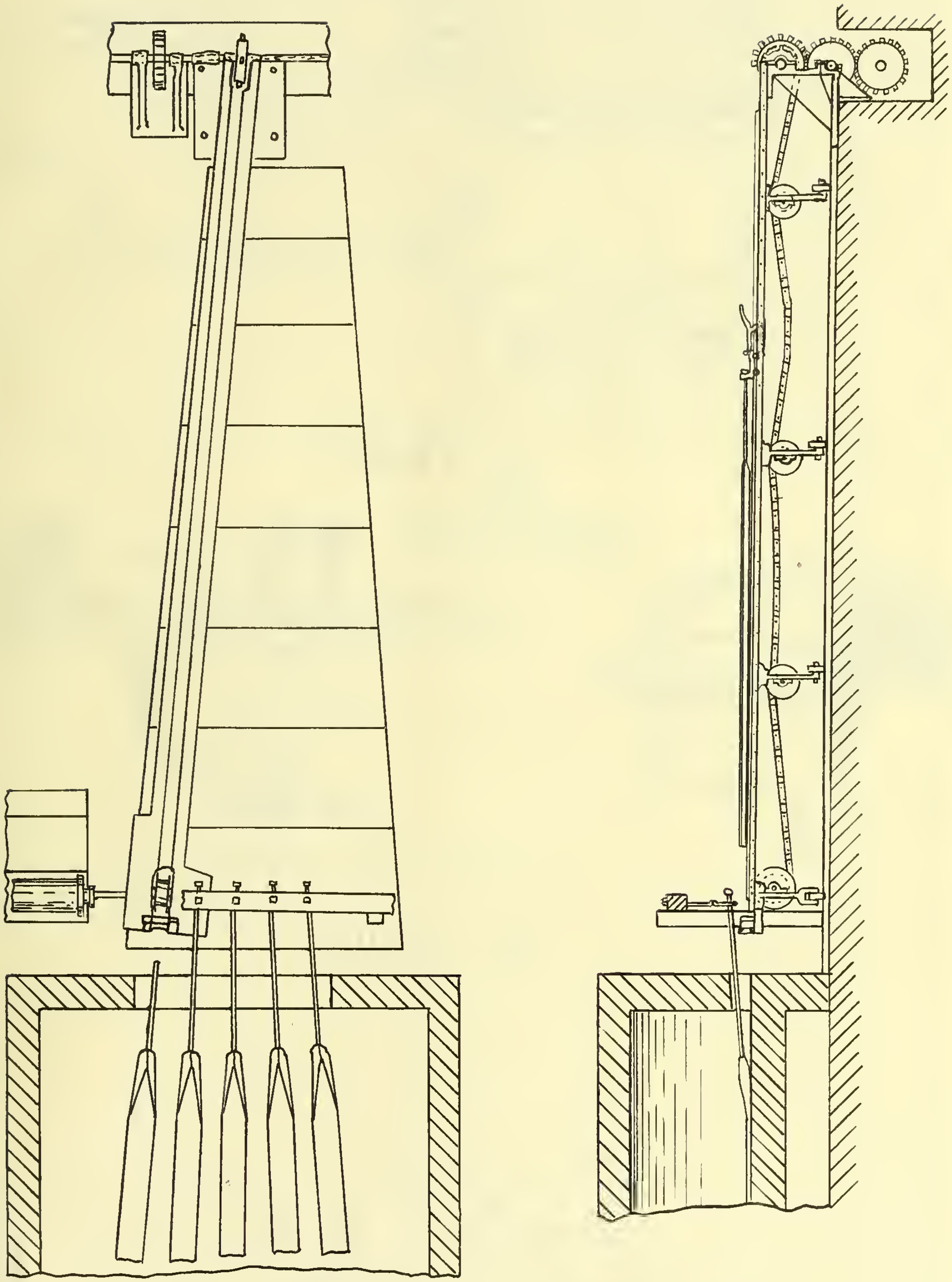

SKELP·
BELL·
BELL HOLDER·
TAG·
FURNACE·
SKELP·
BELL HOLDER·
BELL·
DRAW BENCH·

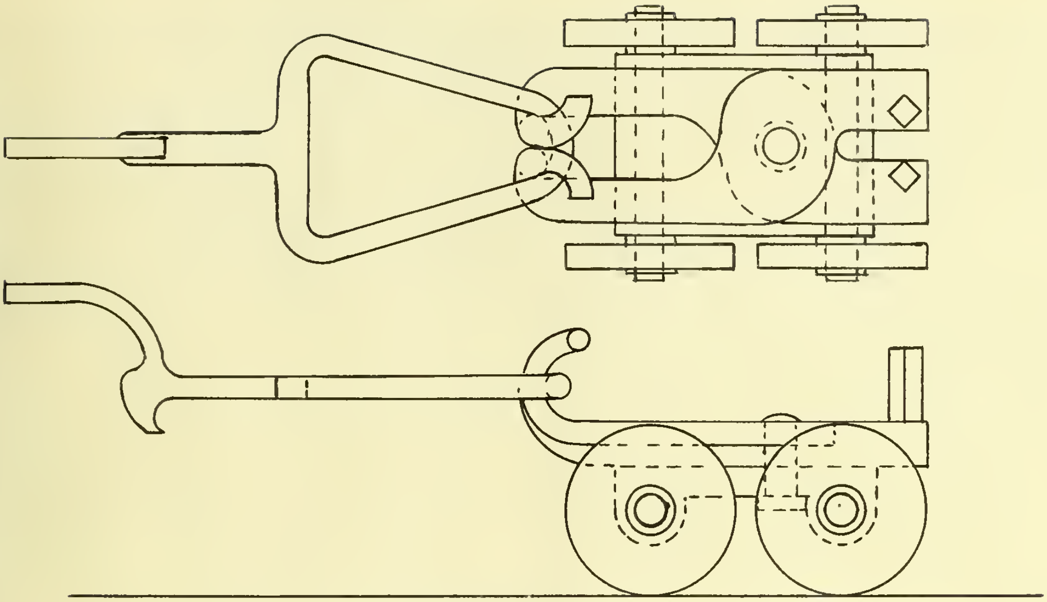
FIGURE ·8·



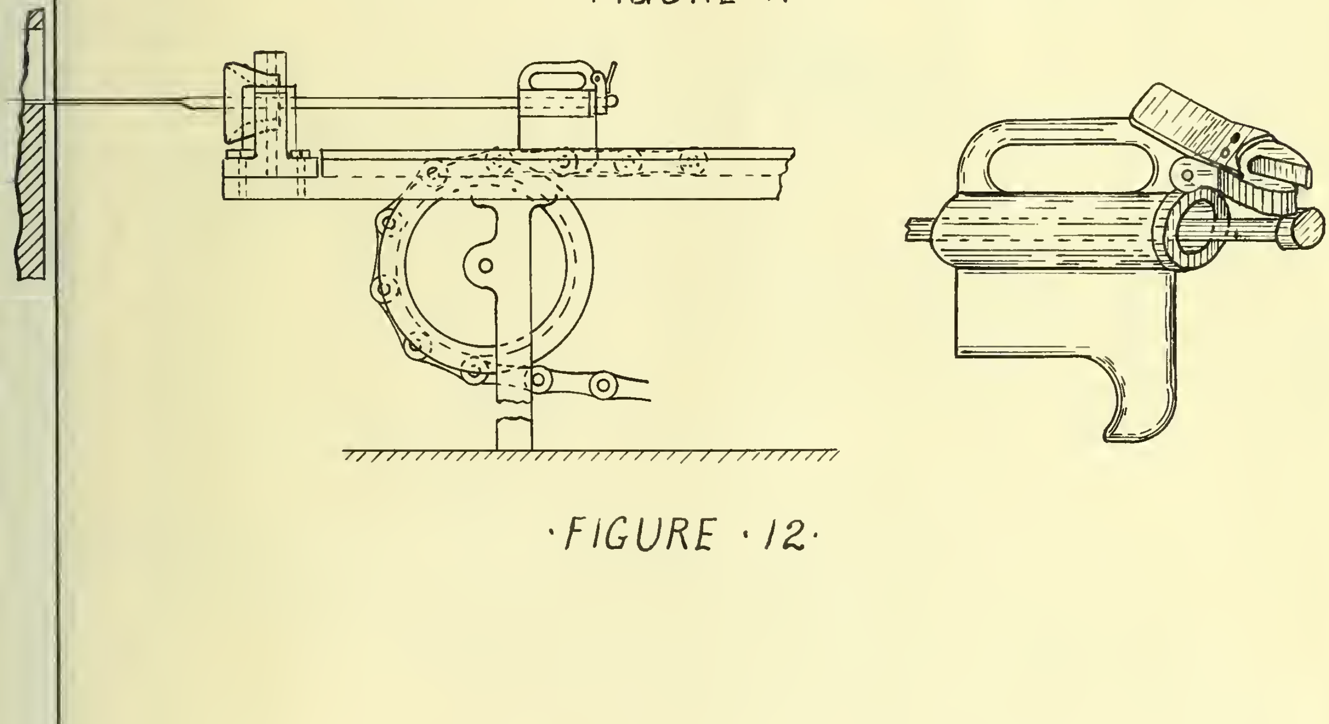
FIGURE·9·



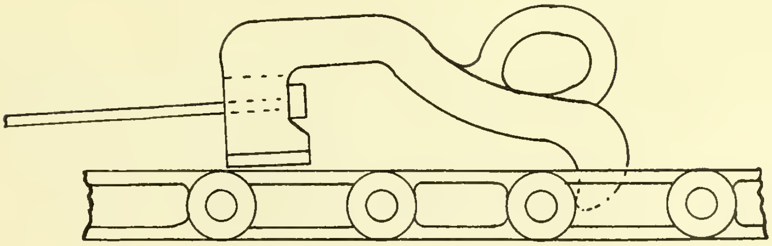
·FIGURE·10·



·FIGURE·11·

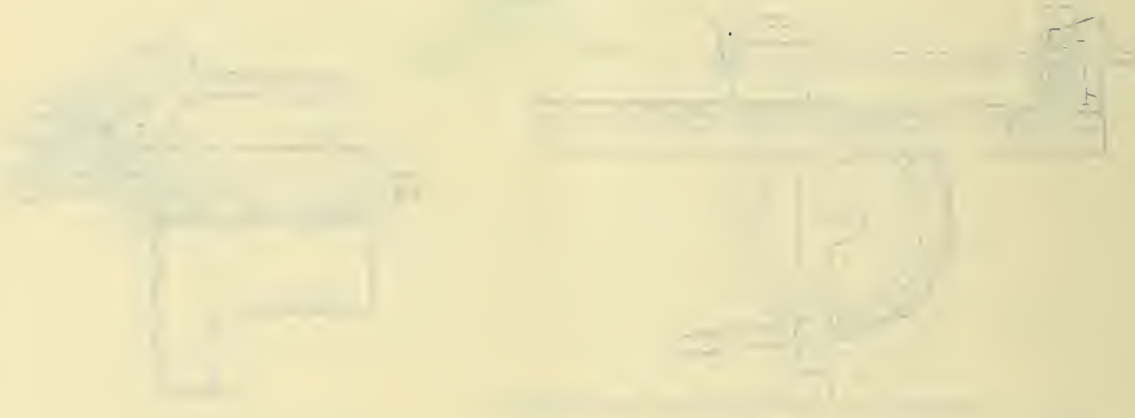


·FIGURE ·12·



·FIGURE·13·

[illegible]



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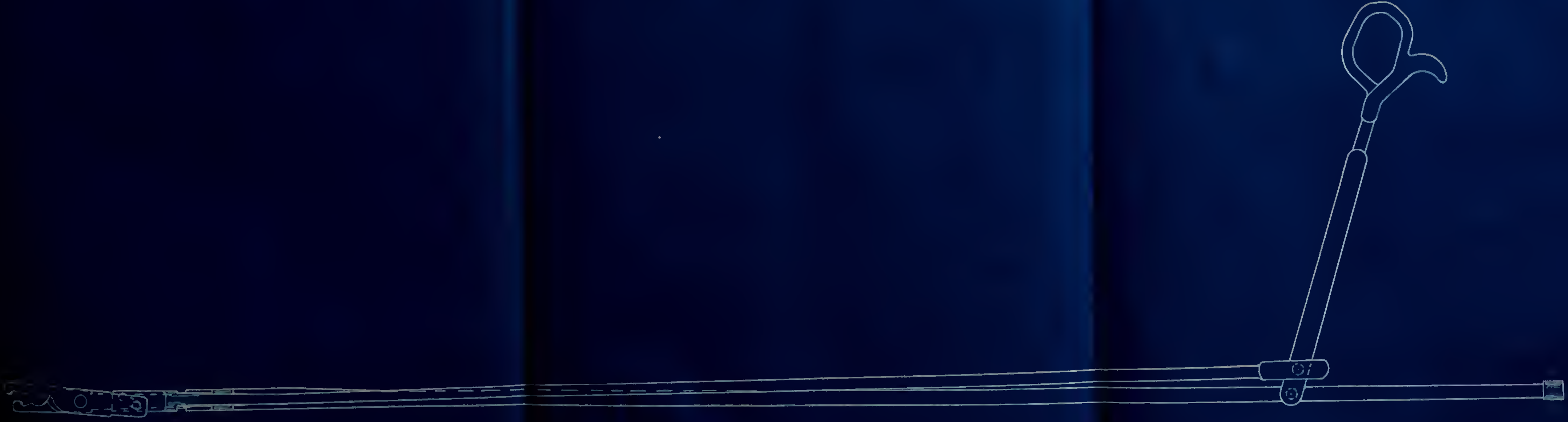
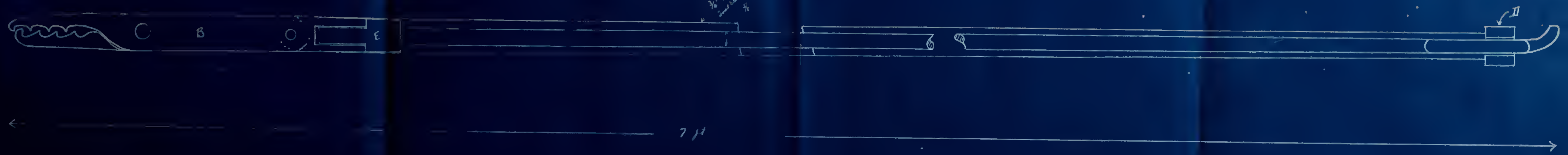
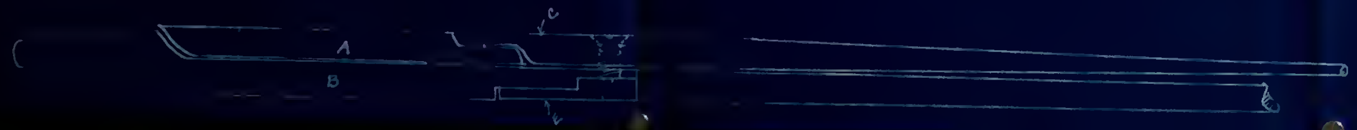
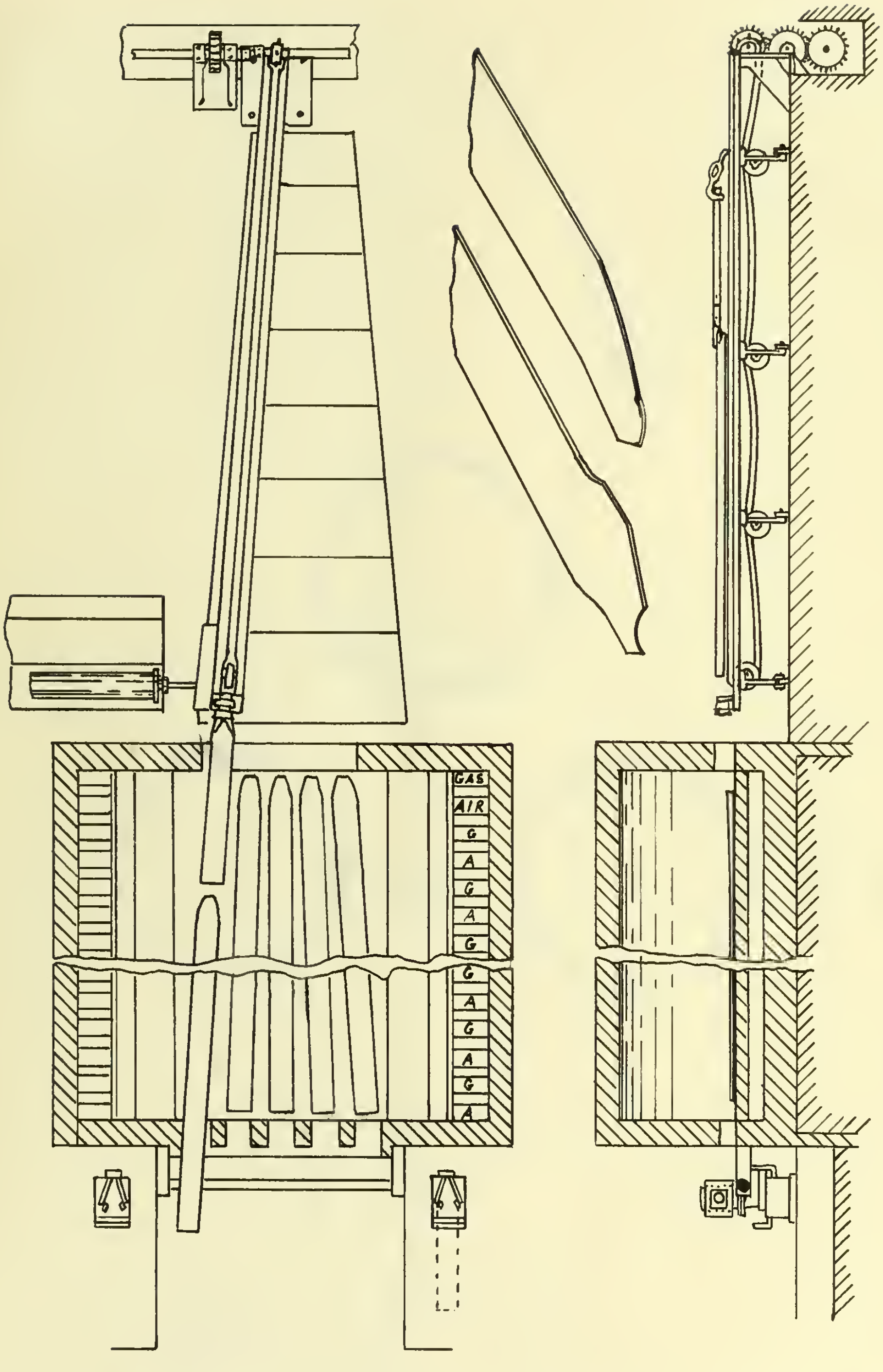



3/8 x 1/4 bar steel
3/4
B
E
D
7 ft

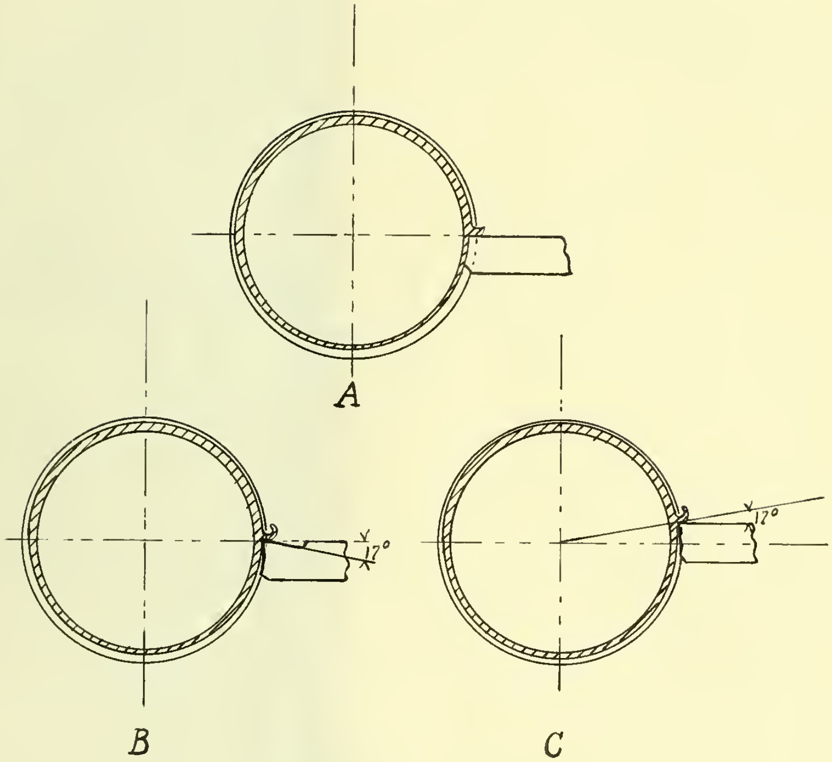

C
A
B
E

[illegible]

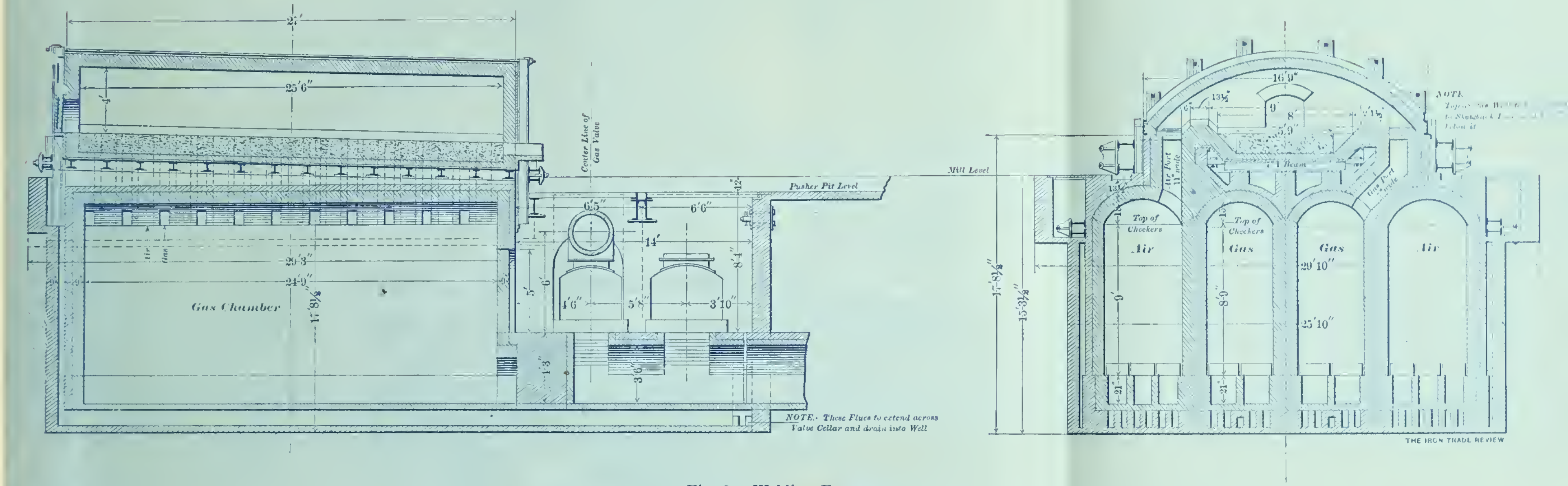
[illegible]



· FIGURE · 16 ·



·FIGURE·17·



THE IRON TRADE REVIEW

Fig. 8. Welding Furnace.

·FIGURE·18·

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